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BULLETIN No. 23

Production of Legume Seed

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HERBAGE PUBLICATION SERIES

BULLETIN 23

PRODUCTION OF SEED OF HERBAGE AND FORAGE LEGUMES

An international exchange of opinions and experiences on the technique
of producing seed of leguminous herbage and forage plants

Edited by
R. O. WHYTE



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More space than is at our disposal would be necessary to convey a correct impression of the forage crop production of a country, and of the seed growing incurred in maintaining the forage areas. It will suffice to note briefly that the arable land of Hungary amounted in 1934 to 5.74 million hectares, to which must be added, as forage-producing areas, approximately 0.66 million hectares of meadowland and 0.53 million hectares of pastures. The following returns from the Statistical Year-book of Hungary for 1934 relate to the production of lucerne seed :

Year.	Total lucerne area. (hectares).	Area devoted to seed production, in percentage of the total area.	Seed harvest, in quintals per hectare.
1932	182,641	20.2	3.4
1933	197,107	22.6	2.2
1934	195,881	21.2	1.8

The data for 1935 are not yet available, but in that year the catastrophic drought reduced the seed harvest below that of 1934. The yearly fluctuations are due to the extreme changeability of the Hungarian climate, as are also the great variations in soil moisture. Variability in yield is closely connected, moreover, with the development of the insects which prey upon seed crops in Hungary, the control of which is one of the most important problems affecting our lucerne seed production ; we look to biological research to bring about a change in the present state of affairs. Of importance from the viewpoints of seed production and breeding is the problem of fertilization. It is necessary here to devote particular attention to the high degree of variability characteristic of lucerne in this respect : from the highly self-fertile to the self-sterile forms all transitions are to be found, and it is the task of the breeder to exercise skill in the correct placing of these different forms for obtaining fodder and seed.

Further, it is important for safeguarding seed production in arid regions—and it is just these regions which furnish the most valuable lucerne seed—that seed production technique should be specialized and developed independently of forage-growing technique. This safeguarding may be realized by ensuring adequate moisture supply during the seed formation stage, that is, by reducing the number of plants per unit area or enlarging the planting distance. Fundamental work in this respect is in progress, and here and there the interest of farmers in these methods is already beginning to awaken. With this special technique, however, absolute freedom from *Cuscuta* and weed content is indispensable in the seed, in order that the farmer can count upon greater profit from his more intensive work.

To-day the production of lucerne seed is still for the most part a matter of individual discretion, and is governed by considerations of the market prices prevailing and whether at the moment there is a prospect of good seed-setting. As shown in the foregoing data, approximately every fifth hectare of the lucerne area is used for seed.

Guarantee of purity, germination capacity and freedom from *Cuscuta* is afforded through the sealing of seed by the State Seed Control Station. If desired, the Station also attaches a special seal guaranteeing the Hungarian origin of such seed as satisfies

this requirement. The term "Hungarian lucerne" defines it as one of the climatically evolved races. Throughout the years natural selection has eliminated all those forms unsuited to the arid Hungarian regions, and has gradually adapted the original population to the environment concerned, thus increasing the general capacity for resistance to cold and drought. Lucerne is most widely grown for seed in the arid regions of the Great Plain, the area coinciding geographically with that of the best wheat.

Hungarian lucerne, considered as a climatically evolved race, is, as has been said, resistant to drought and cold. It is rarely attacked by fungous disease. The flowers are violet in colour; there are, however, strains with more or less variegated flower colour, hybrid lucernes suitable for more northerly regions. Breeding is in progress at the State Breeding Station, Kompolt, and at Prince Eszterhazy's Breeding Station at Eszterhaza.

Lucerne grows well in the better types of sandy soil as well as on heavier soils, especially when the loess or loam substrata are not too deeply situated. A necessary condition is adequate lime content. The good development of lucerne on the alkaline (Szik) soils is particularly interesting, especially when there is a marl subsoil.

The seed is still generally drilled in rows 4.5 in. apart, at the rate of 18 to 26 lb. per acre. Recently experiments with a wider planting distance have been made with a view to safeguarding the seed harvest. Sowing takes place in April. The practice of sowing *without* a cover crop is becoming increasingly popular because the lucerne develops better. It is usual to take seed from older stands, and from the second cut.

The harvesting technique is important. As a rule the crop is scythed, dried in swathes, and afterwards carried to large ricks. At Breeding Stations the crop is cut with a sickle and tied in medium-sized sheaves which are stooked in the field to finish drying. Much less seed is shed when the latter process is adopted; shedding of seed may lead to heavy loss in dry summers. Cutting in the heat of the day should be avoided as far as possible. As the above statistical returns have shown, the yield varies greatly, namely, from 40 to 500 (average 220) lb. per acre.

In threshing, and especially in the use of the huller, care must be taken not to damage or crush the grains.

INJURIES AND DISEASES.

Here lies the crux of the seed-growing problem so far as Hungary is concerned. If drought sets in suddenly when the seed is forming, the grain shrivels and the yield is greatly reduced in quantity. The weather at maturity is thus of decisive importance. Even before this point is reached, however, the fate of the seed crop is uncertain, not so much on account of fungous diseases as owing to depredations by insects, which may have a catastrophic effect.

The larvae of *Otiorrhynchus ligustici* damage the roots. The young, sprouting lucerne is often literally razed to the ground by the larvae of *Sitona* and *Phytodecta* species. Of the gall midges the most dangerous for Hungarian seed production is *Contarinia medicaginis*, which oviposits in the flower buds; galls are produced in the latter and they ultimately fall. On development the larvae inhabiting the buds migrate to the soil, where they pupate. Control is extremely difficult on account of the small size of the midges and the irregularity in the sequence of the broods. There are other species of gall midge, which are less injurious; for example, *Dasyneura medicaginis*, *Asphondylia miki*, *Jaapiella medicaginis*.

Sitona and *Phytodecta* are controlled by spraying with a solution of nicotine or arsenic, by the use of a trapping machine, or even by driving flocks of turkeys through the field, a very effective method of disposing of all kinds of injurious beetles.

Since, on the one hand, the growing of lucerne seed is limited by the colder climate of more northerly countries, and since, on the other hand, seed emanating from regions far south has not been successful with us, it is of great importance that the production of lucerne seed in Hungary should be placed upon a new and firmer basis, on the lines indicated above.

**Lucerne or Alfalfa
(Medicago Species)**

**L. ALABOUVETTE and
P. VOISENAT**

France

There are no very distinct varieties of lucerne grown in France ; the populations cultivated belong to three principal types : Provence, central France, and northern France.

The principal Departements in which seed is grown are : Basses-Alpes, Ardèche, Bouches-du-Rhône, Drôme, Vaucluse, Gard, Aude, Tarn, Haute-Garonne, Gers, Tarn-et-Garonne, Aveyron, Lot, Lot-et-Garonne, Dordogne, Charente-Inférieure, Vendée, Deux-Sèvres, Vienne, Indre, Cher, Indre-et-Loire.

The crop is grown in a rainfall varying from 5 to 800 mm., preferably in lime soil, but not too moist. Its place in the rotation varies, but it comes preferably after cereals.

Seed is sown by machine and by hand, in drills or broadcast, at the rate of 18 to 30 (average 25) kg. per hectare. Lucerne is generally sown under a spring cereal (barley or oats) although sometimes no cover crop is used. Seed is sown generally in March or April, sometimes in the autumn in the south of France.

The use of manures and fertilizers varies widely ; phosphates and potash are generally applied in winter. The land is rolled after sowing, while harrowing or cultivation is carried out in winter ; irrigation is practised in the south. Grazing is only exceptionally adopted. A seed crop is taken from the second or third cut in the south (August 15 to September 15), elsewhere from the second cut (September) ; the crop is cut when the pods are brownish and the seeds yellow and firm. Lucerne has not a marked tendency to shed its seed. The crop is cut with a mower or a scythe and it is sometimes put into shocks. The harvested material remains on the field for from 2 to 15 days, according to region and climate.

Threshing takes place from September to November. The average yield of dressed seed is 100 to 800 kg. per ha. ; the average in the south is 500 kg., elsewhere 300 kg. per ha. From one to five remunerative crops may be taken. Seed is sometimes harvested from the last crop before the field is cleared.

Two insect pests attack lucerne crops in France, *Contarinia medicaginis* Kieff, and *Bruchophagus Gibbus* Boh.

**Lucerne or Alfalfa
(Medicago Species)**

**O. McCONKEY and
L. E. KIRK.**

Canada

The introduction of winter-hardy strains of alfalfa, especially the varieties Grimm and Ontario Variegated, was a necessary forerunner of successful alfalfa culture in Canada. Nearly all the seed produced in Canada belongs to one or other of these varieties ; the Grimm seed being produced in Manitoba, Saskatchewan and Alberta, and the seed of Ontario Variegated in south-central Ontario.

SEED PRODUCTION IN ONTARIO.

The soil types which have proved to be most suitable to alfalfa in this region are well drained loams, and some of the best seed producing areas range from heavy clay to clay loam. Some of the best areas are high in potash. Most of these soils are alkaline in reaction, although one region is quite acid on the surface; the alfalfa roots are however able to penetrate to the "B" horizon, which is alkaline and carries sufficient phosphorus and potash. The nitrate supply is, in most cases, adequate to produce sturdy, seed-producing plants, but not too lush a vegetative growth, which proves unfavourable for seed production.

Light sandy soils which are low in minerals and moisture-holding capacity have proved to be markedly inferior to the clays for seed production.

Seed is sown broadcast at an average rate of 15 lb. per acre, usually in April and May, with a light nurse crop of barley or early oats, or the seed is sometimes broadcast on winter wheat in March after a light snow. Some of the best establishment is obtained by seeding on clean summer fallow in July.

Seeding with a nurse crop usually follows a hoed crop on which barnyard manure has been applied, and there is an increase of the practice of applying 150 to 200 lb. per acre of superphosphate, 16 per cent P_2O_5 , or a similar application of a mixed fertilizer 2-12-6 or 0-12-6 to the grain crop. The seedling alfalfa plants definitely benefit by these manurial practices. There is some indication that the reserves of phosphorus and potash are being depleted by this heavy mineral feeding crop, and that heavier applications of minerals will be needed in the future.

A few farmers cultivate their alfalfa fields to curtail the growth of grass and break the crust on the soil, but this practice is not widespread. Some fields are lightly grazed in the spring and occasionally a field will be clipped back with a mower to make it uniform and to curtail vegetative growth, but these are limited practices.

The crop is harvested by a selfrake reaper, pea harvester with buncher attachment, or mower. The date of cutting is usually late August or early September when the pods are dark brown and the seed firm. The crop is cured in the field, and if the weather is favourable threshing also takes place in the field; if not, it is stored and threshed in the barn.

Yields of seed fluctuate greatly with seasonal conditions, varying from 60 to 600 lb. per acre, with an occasional verified yield of 900 lb. per acre in exceptionally favourable years. The total annual precipitation of snow and rain averages about 32 inches, with 18 inches rainfall during the six months' growing period. A good blanket of snow is an important factor in reducing winter-killing.

Investigations have shown that probably the greatest single factor influencing seed yield is the incidence of the rainfall during the growing and blossoming period. The years of highest yields of seed are characterized by adequate rain to promote normal growth in the early part of the season followed by a comparatively dry, sunny period during the blossoming and fertilizing period. Heavy rains during July are correlated with very low yields. It should also be observed that a very dry period during blossoming, when there are not sufficient reserves of moisture in the soil, causes the blossoms to fall. Equally disastrous low yields occur if there is too much rain.

Wide genetic differences in seed-setting capacities are found among individual plants in these heterozygous variegated strains. Abortive pollen and incompatibility of pollen tube growth are some of the factors which lower yield, and which may be overcome by breeding a strain more homozygous for the seed-producing factors. There are few diseases or insect pests of alfalfa to contend with in this northern region.

When the price of alfalfa seed is high, farmers tend to seed pure alfalfa and take the first crop for seed, but when the price is lowered, a mixture of alfalfa and timothy is sown. The first crop is used for hay, and if conditions prove favourable, the second crop is saved for seed.

The average number of remunerative crops is three to five, though occasional good stands remain for 15 years, when the gradually thinning alfalfa gives way to a succession of Canadian bluegrass (*Poa compressa*), which is especially adapted to heavy clay.

SEED PRODUCTION ON IRRIGATED LAND IN ALBERTA.

Practically all the alfalfa grown in Alberta is produced on irrigated land in the Brooks district. Occasionally very good yields of seed have been obtained, the heaviest on record being 800 lb. per acre. The set of seed from season to season, however, is very erratic, and it is doubtful if the average yield over a period of years would exceed 150 lb. per acre.

The lighter soils have been found to be best for seed production, because on irrigated land it is easier to control the moisture supply. On the heavier soil types, the higher moisture content is conducive to excessive vegetative growth rather than seed production.

Alfalfa seed is generally sown with a nurse crop of grain. Thin stands are found to produce more seed than thick stands. Where alfalfa is being sown mainly with a view to producing seed, the rate of seeding is usually about 6 or 7 lb. and never more than 10 lb. per acre.

The use of mineral commercial fertilizers, especially superphosphate, is increasing rapidly in the Brooks area, as this usually results in higher yields of seed.

The alfalfa seed crop is cut with a grain binder, and the sheaves are set up in long narrow stooks to dry. Threshing is done with a grain-threshing machine, or sometimes with a clover huller or alfalfa huller when these are available.

Those who make a practice of growing alfalfa seed year after year generally give their fields, especially the older ones, a thorough cultivation in the early spring. An alfalfa crop intended for seed is never cut for hay. It is seldom possible to take both a hay and seed crop in one year, owing to the shortness of the season.

The general practice with growers of alfalfa seed in the Brooks area is to irrigate the field in early spring, and then allow the crop to go through the season without a second irrigation, unless the weather has been very dry. If the soil has been very dry just previous to the time of seed-setting, a second application of water is made in order to ensure fertilization and seed development. Irrigation practices for alfalfa seed production, however, have never become standardized, and continue to be a matter of opinion based on individual experience.

The growers of Grimm alfalfa seed in the Brooks area of Alberta dispose of their seed through a co-operative association to which most of them belong. This is known as "The Brooks Alfalfa Registered Seed Growers' Association." The Association operates a plant for cleaning and processing the growers' seed.

SEED PRODUCTION ON NON-IRRIGATED LAND IN MANITOBA AND SASKATCHEWAN.

Almost all the alfalfa seed grown in Manitoba and Saskatchewan is of the Grimm variety. In Manitoba, most of the seed is produced in the inter-lake region, and in Saskatchewan by far the largest quantity comes from the White Fox district, in the northeastern part of the province. The balance of the seed in Saskatchewan is grown under dryland conditions, south of the "Parkbelt" or "Black Soil" zone.

The White Fox district has a grey bush soil that has been heavily leached. It is markedly deficient in humus, nitrogen and phosphates. The dryland soils of the

plains area, on the other hand, are brown in colour and variable in texture, with a dominance of clay loams. The methods employed in these two areas for the production of alfalfa seed are somewhat different from each other, and also from the methods already described for Ontario and Alberta.

In the White Fox district, alfalfa for seed production is sown with a nurse crop of oats or barley at 5 or 6 lb. per acre. This rate of seeding seems to produce a sufficiently dense stand of plants, and good establishment is almost always obtained. A good covering of snow ensures against winter injury. Although moisture conditions during the growing season are favourable, and the plants reach a satisfactory height, very little tillering takes place, the soil being such as to favour reproduction rather than vegetative growth. At harvest time the fields of heavily podded plants have much the appearance of a crop of grain, and are conveniently harvested with a grain binder. Yields of 200 to 400 lb. per acre are quite common. No commercial fertilizers have been used to date. Growers in this district have recently formed an association known as "The White Fox Alfalfa Registered Seed Growers' Association," and a cleaning plant has been established.

Under semi-arid conditions alfalfa is grown for seed in intertilled rows. This method gives better results than seeding in close drills or broadcast, because there is better control of soil moisture, and greater exposure of the plants to sunlight. By spacing the rows 36 to 42 inches apart and giving sufficient intertillage to control weeds, enough moisture is usually conserved to ensure a crop of seed.

Growing alfalfa seed in widely spaced rows is accomplished with a grain drill by stopping up the feed cups that are not required. It is never advisable to use a nurse crop, because grain plants tiller heavily when seeded in spaced rows, and smother the alfalfa seedlings. Two pounds of seed per acre is ample.

It is not possible to take a crop of hay and also a crop of seed in a single season. Even clipping back the alfalfa plants at an early stage is much more likely to reduce the yield than to increase it. Row culture under dry-land conditions is more productive of seed than close-drilled or broadcast seeding. In dry years the difference in yield is very pronounced.

The yield of seed under dry-land conditions varies with the supply of moisture and other factors from a maximum of about 800 lb. per acre to almost complete failure. The average yield over a period of years under dry-land conditions does not exceed 100 lb. per acre.

Unless care is taken in cultivating the rows, they will become ridged. This can be prevented by adjusting the cultivator so that it does not throw the dirt towards the rows. If ridging does occur the soil should be levelled up again by driving crosswise of the rows with a spike-toothed harrow or spring-toothed cultivator.

In threshing alfalfa seed with a grain separator, it is important that the material to be threshed should be perfectly dry and fed through the machine slowly. The concaves should all be in place and adjusted as close as possible. The wind should be regulated so that the unthreshed pods will not be carried past the tailings auger, and they will then be returned to the cylinder a second time. The seed, as it comes from the machine, usually contains quite a proportion of broken pods and pieces of stem which can be removed easily by the fanning mill.

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The general areas of alfalfa seed production in the United States will be described in a later Bulletin in this series. If the reader could visualize a map of the United States showing the average annual precipitation and superimpose on this map the distribution of the main seed-producing areas, it would be clear at a glance that these areas are correlated with low rainfall. Over 80 per cent of the total alfalfa seed production in the United States is in those areas having an average annual rainfall of less than 20 inches, and a correspondingly low relative humidity. This 80 per cent of the alfalfa seed produced may be further classified (as far as production methods are concerned) as coming from one of two general regions—the first, and most productive, being composed of the states of Utah, Arizona, Idaho and California, where most of the seed is produced under irrigation and where the rainfall is usually 5 to 10 inches per annum. The second area is less intensive and is scattered over a wide region lying southeast from Montana to Oklahoma east of the Rocky Mountains. This general region may be characterized as semi-arid with heavy clay loams or silt loams, and the seasonal rainfall is depended upon to produce the crop.

Outside the areas mentioned, seed production is sporadic and apparently dependent upon favourable weather in unusual years, with the exception of portions of Minnesota, Wisconsin and Michigan, where year in and year out the crop is fairly successful.

SOILS ADAPTED TO SEED PRODUCTION.

There can be no doubt that the type of soil has a bearing on alfalfa seed production, but there appears to be a wide latitude of types upon which successful crops are secured. A high lime content is a common characteristic of practically all the soils which produce alfalfa seed. Under Utah conditions, where plenty of moisture is available through irrigation, Whornham¹ found a significant correlation between seed production and index of friability, that is, within the scope of the investigation the coarser textured the soil the better the seed production. In Michigan also seed production is successful on some of the more sandy soils, but good yields have been produced on silt loams and clay loams. In the semi-arid region the soils usually have a high proportion of clay or silt. It is interesting to note that alfalfa seed production is often quite successful on rather highly alkaline soils, particularly in the irrigated sections.

Just what part the use of commercial fertilizers plays in alfalfa seed production has not yet been worked out. Michigan authorities report advantageous use of phosphate and potash fertilizers under certain conditions, but that excessive nitrogen in the soil seems to hinder the setting of seed. It is further suggested that application of fertilizer, especially superphosphate, is beneficial when it provides a better stand and more thrifty plants.

SEEDBED PREPARATION.

The seedbed preparation for seed production in alfalfa is similar to that for hay production. Figure 1 illustrates clearly the result of planting small seeds such as alfalfa on a loose, lumpy seedbed.

RATE OF SEEDING.

A considerable amount of investigational work has been conducted to determine the most desirable type and rate of planting for seed production in alfalfa and although this is not exhaustive and does not cover a sufficiently large number of

different conditions, the results warrant certain generalizations. It seems evident that planting alfalfa in rows or in spaced hills either under irrigation or dry-land conditions will make for higher average seed yields. In very favourable seasons the solid-drilled stand will outyield the row crop, but in average years the reverse is true. Carlson² reports the results of four years' tests under irrigation of the comparative value of hill-spaced, row-spaced, and drilled stands of alfalfa for seed production. His summary table follows :

Treatment.	Average acre-yield for four seed years (lb.)			
Hill-spaced	..	..	..	261
Row-spaced	..	..	..	225
Drilled stands	..	..	..	
2 pounds per acre	..	..	..	234
4 pounds per acre	..	..	..	201
9 pounds per acre	..	..	..	175

(Amount required for a significant difference between treatments—54 lb.)

In three of the four years the row and hill-spaced were superior to the drilled stands.

Very little alfalfa is now being grown in rows for commercial seed production in irrigated districts, and much less than would be expected in semi-arid regions. Montana state authorities highly recommend planting alfalfa in rows 3 or 3.5 feet apart for dry-land conditions. When it is planted in this manner 0.5 to 1 lb. of seed is recommended per acre, and the most successful planter tried was made by fitting a section of a grass seeder box, including the seed cup, in front of or behind the seed box on a corn planter. Seeding in rows can also be accomplished by stopping up enough holes in a drill to give the desired row width. Figure 2 illustrates the use of alfalfa in rows for seed production in Montana. Colorado and other states also recommend planting alfalfa in rows for seed production on dry land.

Difficulties such as harvesting the crop and keeping it weed-free probably prevent a large number of farmers from using the row method, although keeping the ground from ridging by cross-harrowing, or other means, facilitates harvesting. For those who prefer to sow in solid drills, results indicate that it is desirable to sow very thinly, the best rate being from 1 to 3 lb. per acre. This compares with approximately 10 to 15 lb. as recommended for hay production. The most desirable machine to use is an alfalfa drill, but an ordinary grain drill with grass-seeder attachment is very satisfactory. If difficulty is experienced in seeding such a small amount, inert material such as screened coal, or cracked wheat carefully screened can be added and the drill then calibrated until the exact amount of seed planted per acre is determined.

In those sections where the hay crop is more important than the seed crop, it is probably better to plant according to hay production methods and obtain a seed crop only when conditions are favourable.

CARE OF THE CROP AND HARVESTING.

It is usually considered that cultivation of alfalfa for seed, whether in rows or solid drills, is necessary as a weed control measure. The cultivator or spring-tooth harrow is commonly used, as it is not desirable to split the crowns, as may be done by a disk, any more than necessary. Cultivation other than for weed control is generally not profitable, except in thick stands where it is thought a thinner stand would be more productive.

As to which crop to leave for seed, there is a wide latitude possible, depending on length of growing season, conditions during the growing season, and many other factors. In northern sections of the northern states the first crop is usually left for seed, while further south the second crop is on the average best suited for seed production; still further south two crops of seed are sometimes produced in one year.

FIG 1. Discovered ! One little alfalfa plant a month after seeding on a loose, rough seed-bed.

Courtesy T. G. Stewart, Colorado Agricultural Experiment Station.



FIG. 2. Alfalfa in rows on dry land in eastern Montana. Alfalfa is a good dry-land feed crop or seed crop.

Courtesy Ralph D. Mercer, Montana Agricultural Experiment Station.



FIG. 3. Alfalfa seed production on the Ft. HALL Indian Reservation, Idaho. The alfalfa is allowed to start slowly, but when it begins to suffer for water it is irrigated heavily and often until seed is produced. This alfalfa is waist-high and setting a good crop of seed.

Note the willows, indicating a good supply of moisture.



In Utah, Idaho, Montana and other states where the seed is the main crop, it has become increasingly evident that good seed production follows a setback in the spring such as may be caused by sheep grazing until May 15 to 20 or a late clipping at this date, then allowing the alfalfa to produce a crop of seed. Pasturing in the spring must be used judiciously, depending on the moisture supply, length of growing season and other factors, but it is a very common and successful practice in certain areas.

The length of time required to mature a seed crop varies greatly with conditions. With warm, dry midsummer weather a crop may be grown in from 50 to 60 days. Seed produced on the first crop will usually require longer, as much as 65 to 75 days, while if cool weather prevails or the crop is grown at high altitudes as many as 90 days may be necessary to mature a crop.

In many areas where either hay or seed is desired, the hay crop can be left slightly longer than usual until it can be seen whether favourable conditions for seed production develop. If the field shows a tendency to produce numerous pods from the flowers, instead of the flowers stripping off, it often becomes profitable to leave the field for seed. In this way the first, second, or even third crop might be the seed-producing crop.

IRRIGATION OF ALFALFA FOR SEED PRODUCTION.

The importance of proper moisture supply for maximum seed setting is recognized by all growers but it is difficult to establish definite rules for guidance under all conditions. Some growers have worked out fairly successful methods for the control of soil moisture for alfalfa seed production in local areas, but invariably they agree that the same plan does not succeed every year, or in different localities. Experience, backed by meagre experimental evidence, suggests that a limited water supply which will produce a slow and even vegetative growth is most desirable for seed production. The crop should not be allowed to "burn" at any time, and if extra moisture is needed a light irrigation should be given. As a general rule it seems undesirable to irrigate heavily when the crop is just coming into bloom or in fact at any time when such applications tend to produce too much top growth. Irrigation when the pods are filling apparently does not have a deleterious effect, but on the contrary, if moisture is deficient, helps to produce a better seed crop. Carlson and Stewart³ found that clipping the first crop in the bud stage followed by a heavy irrigation produced only 5 per cent as much seed as the check plot without clipping or irrigation at the Utah alfalfa seed experimental farm.

A large seed producer in Idaho has worked out a system whereby the first growth is allowed to continue slowly until water becomes deficient, usually at about the bud stage, when it is irrigated heavily and often until seed is produced. When this field was visited the growth was about 3 ft. high and the plants were heavily seeded; the ground was so wet that young willows were growing in areas of the field, the soil of which was quite sandy. Fields in this region have been reliably reported yielding as much as 1,000 lb. of seed to the acre in favourable years. (See Figure 3).

Further investigations are being made not only on the irrigation problem but on other causes of alfalfa seed crop failures which cannot at present be satisfactorily explained in terms of weather, water relationships, cultural practices or any of the other factors usually regarded as having a bearing on alfalfa seed production.

INSECT PESTS.

In some areas insects cause severe injury to seed setting in alfalfa. This is particularly true of the *Chalcis* fly in the southwestern states. It has also been reported that *Lygus* species cause injury to young buds and flowers of alfalfa in Utah, and the alfalfa weevil (*Phytonomus posticus*) causes considerable trouble in

some of the western alfalfa regions. Many other insects which feed on alfalfa, such as grasshoppers, are undoubtedly a factor in seed production, but those mentioned are apparently of major importance.

HARVESTING ALFALFA SEED.

There is no doubt that well-matured, plump, "true colour" alfalfa seed is superior to immature, shrivelled seed for planting and obtaining a stand. Carlson and Stewart found that plump true colour seed germinated 59 per cent in soil, whereas only 4.4 per cent shrivelled green seeds germinated, and of the seeds which germinated, 65.1 per cent of the true colour plump seed established healthy plants, whereas only 24.2 per cent of the germinated shrivelled green seeds established plants, showing an accumulated advantage in favour of the true colour seed. In order to produce good seed it is necessary to harvest at the proper time, although the time to cut alfalfa for seed may depend on the method of harvesting and threshing and upon soil moisture conditions.

In general, the best time to cut alfalfa is when about two-thirds of the seed pods are black or brown. When cutting is delayed beyond this period, considerable amounts of seed are often lost by shattering in handling.

Many harvesting methods now being used are quite wasteful of seed, for example, harvesting with the ordinary mower followed by a rake. If the mower is used it is better to have a side delivery buncher or windrow attachment which rolls the alfalfa to one side and bunches it so that the machine does not run over it. One of the best machines for harvesting is the self-rake reaper which is used where the amount of material warrants such an expenditure. A header is also sometimes used, in which case the crop is collected in tight header barges and stacked in long, narrow stacks. When the crop is cut with a mower or reaper and drying conditions are good, experimental evidence does not favour the extra labour required to stack the crop compared with that of threshing it from the windrow. Occasionally pea-guards can be attached to the mower cutter bar to advantage, particularly when the alfalfa is in rows.

Infrequently the alfalfa seed crop is cut with a combine, in which case the pods must be fully ripe. This increases the risk of loss from shattering and from seed discolouration due to frost and weather conditions. It is therefore not a favoured harvesting method, but may find a place under certain conditions.

THRESHING.

It is always advisable to handle the crop as carefully as possible, threshing direct from the windrow or stack. The alfalfa or clover huller does an excellent job of threshing, saving practically all the seed in good condition. Where the alfalfa huller is not available the modern grain thresher equipped with alfalfa seed screens and recleaning attachments and operated by experienced threshermen is used with quite satisfactory results.

The combine is also used for threshing by some growers with excellent results. Where the grain thresher is employed all the concaves should be used and set up close. The speed of the cylinder should be reduced about one-third and the air should be regulated so that unthreshed seed pods are not carried past the tailings auger.

CLEANING.

The seed as it comes from the thresher should generally first be run over the common fanning-mill-type of cleaner, but to obtain a complete job ready for market it is usually necessary to use more expensive machinery which is not available to the

ordinary grower but can best be had at a local centralized cleaning plant. Various state laws require certain purity and freedom from weed seeds, particularly noxious weed seeds, before the seed can be sold commercially. It is therefore important that the field is relatively clean and that the seed is cleaned as carefully and thoroughly as possible.

REGISTERED ALFALFA SEED.

The Verification service of the United States Department of Agriculture is a very important one, since alfalfa cannot be distinguished by its seed, and different seed varies greatly in reaction to cold, disease, and other factors. The verification service, however, does not certify as to variety. The State Crop Improvement Associations have therefore co-operated with the International Crop Improvement Association with the object of certification or registration of recognized and recommended varieties so that when a grower buys such seed he is quite certain of the kind he is purchasing.

The International Crop Improvement Association has adopted standards for the inspection and certification of alfalfa. Seed which is registered or certified (these two terms are used interchangeably, but the former is becoming more popular) by State Crop Improvement Associations must qualify from three standpoints: (1) Foundation Seed, (2) Field Standards, and (3) Seed Grade Standards. The fields that are eligible to produce registered seed must first have been planted with seed that traces back to the recognized original source for the particular variety under registration.

Field Standards include such items as having the field entirely free from alfalfa plants before planting, field inspections for the purpose of checking for varietal purity, weeds, etc., and for isolation from other alfalfa fields. The Seed Grade Standards include grading, cleaning in authorized cleaning plants and grade requirements.

If the seed meets all the requirements the bags are tagged and sealed and are then eligible to be sold as State registered or certified seed.

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Red Clover (*Trifolium pratense*)

R. P. HAWKINS

England

There are three types of English red clover, each with distinct characteristics.

1. Early Flowering Red Clover.

This type, which is known also as Broad Red Clover and Double-cut Red Clover, is the quickest growing type and frequently provides grazing during September and October in the year of sowing. It starts growth early in the following spring, when it may be lightly grazed, and it is the usual practice to cut the crop for hay in June. Subsequently it again makes rapid growth and provides either grazing during August and September or a second crop of hay. Early Flowering Red Clover is a true biennial and few plants persist after the second year.

2. Late Flowering Red Clover.

This type, which is also known as Single-cut and Single-cut Cowgrass, makes little growth until the late spring in the year after sowing. Growth is then very rapid and Late Flowering Red Clover can produce very heavy crops for hay in June. It makes relatively little growth during the latter part of the year, but as the plant will persist for two or three years it is of particular value for leys of long duration, especially when they are required to provide crops of hay. Late Flowering Red Clover, moreover, can be grown successfully on land where Early Flowering Red Clover is liable to fail.

3. Extra Late Flowering Red Clover.

The only representative of this type in England is Cornish Marl which originated in the north of Cornwall. It starts active growth much later in the spring than either of the other types, but it is very persistent and will stand for four or five years.

SEED GROWING DISTRICTS.

Red clover seed is produced in the east and south of England, the principal districts being the eastern counties of Norfolk, Suffolk, and Essex and those adjoining, and the Cotswold district of Gloucestershire and Oxfordshire with the southern counties of Dorset, Hampshire and Wiltshire. These districts produce seed of both the Early Flowering and the Late Flowering types of red clover. The red clover seed crops in Cornwall are confined to the Wadebridge district in North Cornwall which specializes in the Extra Late Flowering type.

SOIL AND CLIMATE.

In the eastern counties of England with their low rainfall, the heavier types of soil are preferred for clover-seed production and particularly those soils which are well supplied with chalk.

In Dorset, Wiltshire and Hampshire, however, the best seed crops are usually obtained on soils of medium loam, preferably those overlying chalk, while quite a fair yield may be obtained from thin loams if there has been sufficient moisture before the plant is in bud.

Fine weather for harvesting the crop in August and September is of considerable importance if a purple sample of seed with a good germination is to be secured.

SOWING, CULTIVATION AND MANURING.

In the eastern counties and also in the Cotswold district, red clover is sown with a drill under a nurse crop of wheat or barley. The seed is sown in April at the rate of 10 to 14 lb. per acre in drills 6.5 to 7 inches apart. In these districts red clover is usually sown alone for seed production.

In Dorset, Hampshire and Wiltshire, on the other hand, the seed is usually sown broadcast and while it is sometimes sown alone, it is more usual to mix with it a peck of either Italian or perennial ryegrass.

The crop receives little cultivation apart from rolling and harrowing when it is sown. A further rolling is sometimes given in the autumn and in the following spring, while some growers remove weeds, either by pulling or by spudding them from the crop during its growth.

It is unusual to apply manure of any kind to a crop of red clover seed, although the nurse crop of wheat or barley frequently receives phosphatic manures. The heaviest yields of Late Flowering Red Clover seed are, in fact, frequently obtained from the less fertile soils.

TIME OF HARVESTING.

The time of harvesting varies according to the type of red clover.

1. Early Flowering Red Clover comes into flower at the end of May and early June and is then cut for hay. The second crop flowers in August and is left to harvest for seed in September.

2. Late Flowering Red Clover flowers a month later and is in full bloom in July. The first crop is left for seed and is harvested in August.

3. Extra Late Flowering Red Clover. The first crop does not come into flower until August and the seed is harvested in September.

Red clover seed ripens rather unevenly; in a dry district and in a favourable season the crop is left standing until most of the flower heads are brown and contain purple seed.

METHODS OF HARVESTING.

In the eastern counties the crop is usually cut with the mowing machine and then raked into small heaps. Other growers use the self-delivery reaping machine which cuts the crop and leaves it in small heaps. Others, again, use the self-binder to cut the crop and leave it loose in rows, or if the season is favourable it is sometimes tied into sheaves.

In the south of England the reaping machine is considered by some of the largest growers of clover seed to be by far the best proposition.

After cutting, the crop is left in the field for about a week until all green material which it may contain has dried, when it is carted into stacks. Cutting and carting are done early in the morning during hot weather to avoid loss of seed from shedding.

In the southern counties the ventilation of the stack is an important, one might almost say a vital, factor; most growers are careful to see that ventilation of the stack is obtained by using cribs, fold hurdles, faggots or straw and in fact anything that will create a current of air continually through the stack.

Early Flowering and Late Flowering red clover crops are saved for seed in the year after sowing and are then ploughed up. In Cornwall, however, it is usual to save the seed of Cornish Marl from crops which have been down for a longer period and more than half the seed is frequently obtained from crops which were sown down two years previously.

THRESHING.

The seed is threshed from the stack by a portable "huller" which contains a drum to remove the clover heads from the stalks and also a "cannon" to rub the seed from the heads. The seed is partly dressed by this machine but is subsequently re-dressed with more elaborate machinery to remove all traces of weed seeds and other impurities.

The seed can be threshed when the pod is sufficiently dry for the seed to be rubbed out. In the eastern counties, threshing takes place from October onward, and in a favourable season, Late Flowering red clover may be threshed in the field. In the southern counties, however, where the autumn is much more humid than in the eastern counties little clover seed is threshed in an ordinary season until the end of November. Further west, in Cornwall, the seed is not threshed until January, February and March.

INSECT PESTS AND FUNGOUS DISEASES.

In some seasons there is considerable loss of plants during the winter from clover stem rot (*Sclerotinia trifoliorum*) and from attacks of eelworm (*Anguillulina dipsaci*).

Clover seed weevils (*Apion*), by destroying the developing seed, are the cause of considerable loss in seed growing districts.

Clover scorch (*Gloeosporium caulivorum*) is prevalent in some seasons and causes the clover heads to fall from the plant before the crop is harvested.

ACKNOWLEDGEMENTS

Details of the methods of harvesting red clover seed in the southern counties have been supplied by H. H. Dunn, Salisbury, while Alex Gregg, Truro, and J. H. Humphreys, Launceston, have given particulars concerning the harvesting of Cornish Marl.

Red Clover (*Trifolium pratense*)

C. JAMES

Wales

Two distinct types of *Trifolium pratense* are grown for seed in Wales, an extreme form of late flowering in Montgomeryshire, and a hardy broad-leaved type in the Vale of Clwyd.

Nothing authentic is known of the origin of the Montgomery Late Flowering Red Clover, which has been cultivated for seed in the eastern part of Montgomeryshire for many years. A late flowering strain of wild red is found in many of the old pastures and it is probable that Montgomery clover is the result of natural crossing between this wild red and cultivated clovers. Some farms which are to-day producing seed have done so almost continuously since the early part of last century. An interesting point is that many growers have made it a practice to sow "seconds." It is quite possible that in the early days of seed production this was an important factor in fixing the strain and later in maintaining its trueness to type.

The past generation of farmers realized that clover seed produced in this district was more reliable than seeds purchased from other parts of the country, but it was not until tests were made at the Welsh Plant Breeding Station that it was discovered to be a distinct variety.

Conditions in the Montgomery area may generally be considered favourable for production of late-flowering red clover for seed. The soil is mainly heavy loam with clay subsoil. The rainfall is moderate, below the general average in Wales, but crops are seldom affected by drought. The bulk of the land on which seed is produced is about 600 feet above sea level, but crops are often taken from land with an altitude of 1,000 feet. There is very little variation either in bulk of crop or weight and quality of seed whether produced at 400 or 1,000 feet.

Until the last 20 years it was the general practice to take seed in the first harvest year; since arable acreage declined in favour of long leys these have been used for seed production and it is now the custom to take seed at any period during the life of a ley, in some cases up to the fourth, fifth or sixth year.

Seed is broadcast in the usual cereal nurse crops at the rate of from 8 to 10 lb. per acre, often with a little ryegrass. Most growers take a hay crop in the first year; the aftermath is grazed with sheep and a dressing of basic slag given in the autumn. In the following spring it is grazed hard until the beginning of June. Experience has proved that to graze bare during the month of May gives the most satisfactory results. Apart from such weeding as may be necessary, no further attention is given until the crop is ready to harvest, usually in early September. As is common with all late-flowering types, a succession of flower heads is formed. Cutting takes place when the grower considers that the majority of these are ripe.

The crop cannot be regarded as heavy yielding. The weight of seed depends to a large extent on the number of early-formed heads which shed before the bulk are

ready. A fair average is about 3 cwt. per acre of dressed seed, although in the best seasons up to 5 cwt. per acre is sometimes obtained.

Many of the fungous diseases and insect pests that appear to do so much damage to clover crops in some parts of the country are practically unknown—for example, there is no clover sickness. Occasional damage is caused by *Gloeosporium* and in dry seasons the grub of *Apion* weevil may be troublesome, particularly in the low-lying areas. No measures have so far been taken to combat either of these pests.

Under the guidance of Professor R. G. Stapledon, an Association of Growers was formed and seed crops were inspected in the field by specialists from the Welsh Plant Breeding Station. All strains which were not of the true type were eliminated. The practice of field inspection is still continued. Recently the Growers' Association has installed an up-to-date cleaning plant at a central depot where all the seed is now cleaned and tested before being marketed.

Seed production in the Vale of Clwyd is mainly confined to a hardy strain of Broad Red clover, which has been cultivated in that area for many years and is probably one of the best of this type in cultivation. Excellent crops are produced and the seed is sold with a high standard of germination. This seed is usually taken in the first harvest year as a second cut, the first cut being for hay. It is not uncommon for seed to be taken in the second harvest year; when this is done the general practice is the same, an early cut for fodder and the aftermath cut for seed.

The yield is usually higher than that of the late-flowering type in Montgomeryshire and in an average season would reach 4 to 5 cwt. per acre.

The acreage has not varied much during the past few years. Owing to the transfer from arable to pasture the area harvested is somewhat less than it was about 20 years ago. Sowing and harvesting is on the same lines as in Montgomeryshire.

The Vale of Clwyd Seed Association provides for inspection of crops for the purpose of certifying stocks.

The names Montgomery and Vale of Clwyd are well known in connexion with seed clover, and both types are becoming more popular.

Red Clover (*Trifolium pratense*)

R. FLEISCHMANN

Hungary

RED clover in Hungary is the forage plant of the moister districts in the south and west of Transdanubia. The further one penetrates into the heart of the Great Plain, the greater are the risks attending its cultivation. If lucerne constitutes the permanent forage plant *par excellence* for the arid climate, it is obvious that red clover, as a plant of the moist climate, cannot compete with lucerne. Since there is only a limited amount of suitable land in what remains of Hungary to-day, the area occupied by red clover is relatively low in comparison to that occupied by lucerne. It appears almost as if the lucerne area is increasing at the expense of the red clover area. The following are the returns for the latter :

Year.	Total red clover area. (hectares).	Area devoted to seed production, in per- centage of the total area.	Seed harvest in quintals per hectare
1932 ..	140,620	18.1	2.4
1933 ..	126,528	18.5	1.7
1934 ..	126,100	21.3	1.8

It is striking that the average quantity of red clover seed harvested for the three years, 2.03 quintals per hectare, is lower than that of lucerne seed for the same period, 2.47 quintals per hectare. In the case of red clover, also, a somewhat lower proportion of the total area is set aside for seed production.

The red-flowered cultivated red clover, like lucerne, was introduced into Hungary from the west at the end of the eighteenth century. But in addition to this there is found, especially in the Great Plain, a Hungarian perennial, wild red clover, an autochthonous form described by Heuffel in 1885 as *Trifolium pratense* L. var. *pilosum*, and by Hegi as var. *spontanæum* subvar. *pilosum*. This form generally has a red flower, but white-flowered plants also occur. The plant has been used as breeding material at the State Plant Breeding Station, Mezöhegyes.

Contrary to the practice with lucerne, red clover is sown, more frequently than not, under a cover crop (generally barley). It has more exacting requirements in regard to soil moisture than the deep-rooting lucerne. In general it is better than lucerne as a crop for preceding others, because as a two-year plant it can easily be interpolated in any cropping system, but principally because the root debris left is concentrated mainly in the upper soil layers, enriching their humus content more than could be done by old lucerne. Red clover is generally followed by wheat.

Sowing takes place in April, the seed rate being 13 to 18 lb. per acre. The seed cut is taken in the second year, browning of the flower heads indicating that the seed is ripe. Mowing is done with a scythe, the crop is dried in swathes, placed in small stacks to finish drying, and is then carried to large stacks. Threshing is done in August or September. Yield varies from 40 to 500, and averages 200 lb. per acre. Whether red clover is used for fodder or for seed in the second year depends in the first place upon the general organization and convenience of the farm, but also upon the extent to which *Apion trifolii*, the arch-enemy of the red clover seed grower in Hungary, makes its appearance. As seed is generally taken from the second cut, it is important to use the first cut as far as possible for green fodder, because if it is allowed to dry as hay the beetles have time to reach maturity and make a mass attack upon the flowers of the second (seed) cut. After the first cut, as soon as the stubble begins to shoot afresh and the typical traces of *Apion trifolii* are observed on the leaves, the field must be sprayed *immediately* with a solution of 100 litres water, 300 grm. nicotine, 1.5 kg. potassium soft soap. Spraying should be repeated as the clover grows. Collection with various trapping machines also reduces the number of beetles very considerably. The energetic use of these measures ensures a good seed crop.

An important question for districts in which both red clover and lucerne are grown for seed is the avoidance of permitting the two species to become mixed with one another, as may easily happen in threshing, etc.

Special measures such as those adopted in the case of lucerne, that is, growing with wide planting distances, have not yet been attempted.

Red Clover (*Trifolium pratense*)

E. ÅKERBERG

Sweden

THE growing of red clover in Sweden was begun in the eighteenth century, but it did not become at all widely distributed in central and south Sweden until the middle of the nineteenth century, and not until the end of the century in the north. According to the statistics available, which, however, are somewhat unreliable, the area now devoted annually to the growing of red clover seed in Sweden is from 16,000 to 18,000 hectares. The country's own requirements amount to 4,500 to 5,000 tons per

annum. Home production can in the main cover these requirements. As there is always a certain amount of early clover imported, there is always a certain amount of exportation also, the extent naturally varying from year to year. Import, however, has decreased considerably within recent years. The imported seed is made recognizable by staining with eosin.

Principally the single-cut varieties (late red clover) are grown for seed in Sweden. Only in the south (Scania) and in some parts of central Sweden (Östergötland) is seed of the double-cut or early red clover produced, and the area it occupies is small. The early clover is grown for fodder only in Scania, along the west and eastern coastal regions of Götaland, and in the Islands of Öland and Gotland. The observations which follow relate exclusively to the production of late clover seed.

Technique varies fairly considerably in the different parts of Sweden because of the widely different climatic and soil conditions. Red clover is grown for seed from the farthest south up to the 63rd and 64th northern parallels, but only in very isolated instances further north than this. Between 60.5° to 64°N seed growing is mostly limited to the best areas along the coast of the Gulf of Bothnia.

On account of the great differences in climate and soil prevailing in the red clover areas, numerous races have been evolved, differing from one another in time of flowering, winter hardiness, resistance to disease, and so forth. This is readily explained when it is remembered that red clover has proved to be one of the most susceptible of plants in relation to soil, climatic and other environmental conditions. These races constitute the so-called local varieties; many have been grown in the same place for several years, occasionally for more than 50 years.

Old local varieties of this kind have recently been the subject of trials on a large scale in the most diverse places. The final conclusion drawn from these trials was that these old local varieties are of very great agricultural value for the district in which they have arisen and to which they have become adapted, and as a consequence reproduction of seed of the best of them is now carried out on a relatively large scale. Herein special importance is attached to the question of terrain, which is so chosen that the selective action of the environment may affect the characters of the variety as favourably as possible, in such a manner that it becomes more suitable for the district concerned. The following are some of the local varieties: Karaby and Spannarp in the south of Sweden; Ultuna in Central Sweden, and Bollsta and Offer in the north of Sweden. Some of the northernmost varieties have arisen from the hybridization of *Trifolium pratense* var. *sativum* with *T. pratense* var. *spontanum*. In addition to these local varieties, bred strains are also grown in Sweden for seed production. In sowing red clover the choice of variety, therefore, is of extraordinary importance in Sweden.

The production of red clover seed takes place on almost every kind of soil. An exception is made of very dry soils, those which are deficient in calcium, and those in which the water table is very high; soils with a high humus content are also avoided, as they produce too luxuriant vegetative development. Red clover may occupy various positions in the cropping system, but whenever possible it is grown after roots.

It is nearly always sown in a cover crop, which is generally a summer cereal (oats or barley), but it may be grown in winter cereals also and in a mixture which is used for green fodder. For the most part it is sown at the same time as the cover crop, in the south of Sweden in April, and in central Sweden and the north from April to May. Sometimes in the south of Sweden sowing of the red clover is postponed until it has been possible to control weed growth in the cover crop by harrowing.

As a curiosity it may be noted that formerly, in central and northern Sweden, red clover (not hulled) was often sown down in late winter directly into the snow,

whereby it was possible to ensure uniform distribution. The method is still employed here and there, but very rarely.

In the south and often also in central Sweden, red clover is grown as a pure culture. The seed rate is 12 to 20 kg. per hectare, and both broadcast sowing and drilling are employed; in the latter case the distance between the rows is fairly small (10 to 20 cm.). A wider planting distance, 30 to 50 cm., has certainly been tried in Sweden, but this practice has gained little vogue.

In central Sweden, and particularly in the north, a different method is adopted. Red clover seed is grown here mostly for home consumption. In a one-year ley, and occasionally also in older leys, in which a good stand of red clover has developed, a portion is set apart and allowed to run to seed. The stand of these leys is composed of red clover together with *Phleum pratense* and often with *Trifolium hybridum* also. A pure sowing of red clover is unreliable in these regions. Broadcast sowing is generally employed, the usual seed rate being 15 to 20 kg. red clover per hectare and 6 to 10 kg. *Phleum pratense*.

Manurial treatment varies greatly on the different farms. If possible, the cover crop received a dressing of some potassium and phosphoric acid. Only a small dose of nitrogen is applied to avoid the lodging of the cover. In the following year, that is the first harvest year, a dressing of potassium and phosphates is generally given, as red clover has shown itself to be very responsive to these two nutrients. The cultivation involved consists of rolling and of hoeing the weeds. The latter operation has to be done by hand because of the closeness of the rows.

In Sweden, contrary to the practice in more southern countries, it is the first cut from which the seed crop is taken. If the first cut of late red clover were used for hay, the second cut could not ripen for seed. As the flowering period is prolonged, the time of ripening is comparatively irregular. In order to ascertain the correct moment for harvesting, seed-setting in the different flower-heads must be examined. In this respect considerable differences are exhibited, produced by the influence of the weather and by visits from insects. The insects which in Sweden fertilize red clover are chiefly *Bombus* species, and *Apis mellifica* is also recorded. It is usual to harvest when the heads with the best seed-setting are black-brown in colour, and when the colour of the seeds in the capsules is yellow to yellow-violet. If harvesting is done too early shrivelled seeds are obtained, if too late there is a tendency for the heads to fall. In order to avoid seed loss, red clover is often cut when wet with dew.

Harvesting takes place in August and September. In smaller fields, mowing is done with a scythe, and on larger areas with a side-delivery reaper. The crop is dried on frames similar to the Heinz type, but provided with one cross-piece (Swedish 'krakstör'); or, especially in central and northern Sweden, on Swedish fencing. It is left on the frame until it is completely dried and has been allowed the necessary time to condition, a process which generally requires from 10 to 20 days.

As a rule, only one year's seed harvest can be taken from a field, as the stand becomes too sparse in the following year. Red clover seed is thus taken in the year after the cover crop has been harvested. Only when it is desired to obtain élite seed is an attempt made to obtain it from older leys, the seed from which is considered to furnish more persistent and disease-resistant plants.

Threshing generally takes place in winter, from December to February, as the seed capsules split open better under frosty conditions. After threshing with an ordinary threshing machine, capsules which are still shut are opened by means of a clover huller. Threshing and hulling constitute the most difficult processes, as it is easy for the seed to become damaged thereby. With careless hulling the embryos are often broken, thus rendering the seed useless. In Sweden both rubbing and the subsequent cleaning are often done at co-operative cleaning centres.

Seed yield naturally varies in accordance with prevailing conditions. According to one computation the average yield of red clover seed for the whole of Sweden for the years 1921 to 1931 was 282 kg. per hectare. Yield is greater in the south than in the north, for example, in Scania in the south, the average yield for the years 1920 to 1934 was 355 kg. per hectare.

Red clover is often fairly heavily attacked by fungi and insect pests in Sweden. *Sclerotinia trifoliorum* is the cause of great damage throughout the country, but especially in the south, as the development of this fungus is particularly encouraged by mild and wet winters. Since several weeds may be attacked by *Sclerotinia*, its vitality can be maintained in the soil for long periods. There are striking differences in the degree of resistance exhibited by the different red clover varieties. On the other hand, however, the existence of different races within the fungous species has been determined. It is possible that now and again damage attributed to *Sclerotinia* is actually caused by *Mitrula sclerotiorum*.

Another fungus which fairly often attacks red clover is *Gloeosporium caulivorum*; injury caused by this species may be seen almost everywhere the crop is grown, but as a rule it is not so devastating as that caused by *Sclerotinia*.

The eelworm, *Tylenchus devastatrix* (= *Anguillulina dipsaci*) is rare except in the south of Sweden, but here it is a very dangerous parasite of clover stands. Like *Sclerotinia trifoliorum*, it is very difficult to control. In this case also, however, varying degrees of susceptibility within the individual clover varieties have been observed. It would appear that varieties entirely immune to clover rot and eelworm attack may be obtained through careful selection.

The third dangerous enemy of red clover in Sweden is *Apion* (*A. apricans* and other species). These insects have caused great damage in south and central Sweden, particularly in the last few years. No means of control are yet known. This problem, together with that of clover rot, is at present the subject of intensive study at the Swedish State Phytopathological Station.

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Red Clover (*Trifolium pratense*)

L. E. KIRK and
R. MacVICAR

Canada

SEED production of the double-cut type of red clover in Canada is more or less incidental to its production for hay. The majority of farmers grow red clover primarily for forage, and they utilize the second crop for seed purposes only when it appears profitable to do so. It is not a general practice to grow red clover for its seed alone, except in the case of the late single-cut types. In Canada and the United States there is a great preponderance of the double-cut type.

Red clover is usually seeded in a mixture with timothy, the rate varying from 6 to 8 lb. of the former and 4 to 8 lb. of the latter per acre. It is always seeded with a nurse crop of wheat, oats or barley. Clean, well-tilled and firmly compacted land, which has produced an intertilled crop in the previous year, is a prerequisite to successful red clover culture. Occasionally the clover is sown without timothy, and under these circumstances some growers have found that a seeding rate of 4 lb. per acre is ample. The grass seed is broadcast by an attachment on the grain drill, or the seed may sometimes be sown by hand under special conditions.

Good establishment of red clover depends largely on soil preparation and seeding sufficiently early to take advantage of the better moisture conditions which obtain in the spring of the year. Poor cultural methods and late seeding are often responsible for failure, since unless the plants become well established before a period of hot dry weather, which frequently occurs in midsummer, they are likely to succumb through competition with the nurse crop. After the grain is harvested the clover plants make rapid growth during the autumn, so that a good plant cover is usually obtained by the time cold weather sets in.

Unless the clover seed which is used derives from locally grown seed, or strains of northern European origin which are winter hardy, more or less winter injury is apt to occur. This may be quite severe with varieties of clover which are not acclimatized.

In the year following seeding the timothy is not conspicuous, and a pure stand of clover is usually obtained. In the second year after seeding, on the other hand, the timothy makes a strong vigorous growth, and the amount of clover present is often negligible. As most of the clover is of the double-cut type, the first crop is cut for hay when it comes into bloom about the third week in June. If haying is delayed much beyond the proper time, the second growth is liable to be light and mature too late to permit harvesting a crop of good quality seed. Both the yield and quality of the seed crop depend to a considerable extent on the time that the hay crop is harvested.

When the hay crop is removed at the proper time, the seed crop is ready to harvest about the last of August. The seed is ripe when the heads have turned a dark brown. Harvesting of the seed crop is accomplished by means of either a

self-rake reaper or a hay mower. After cutting with a mower the clover is raked into windrows and put up into small bunches to cure. Various types of bunching attachments for the mower are now in use, by which the raking operation is avoided. Losses of seed due to shattering are lessened by cutting when the clover is still moist with dew.

When machinery is available and weather conditions permit, the crop is usually threshed from the field. Otherwise the clover is placed in stacks, or in the hay mow, for threshing at a more convenient time. Clover hullers are used to some extent, but the ordinary grain separator, equipped for clover threshing, is the more common method. If the material has been well cured, and the machine carefully adjusted, excellent results in threshing the crop may be obtained.

Yields of clover seed vary considerably from year to year, depending on various factors. Generally, the yields range from 100 lb. to 240 lb. per acre for the double-cut red clover, and from about 150 to 300 lb. for the single-cut type. Only one remunerative seed crop of the double-cut type is obtained.

It is very desirable that red clover which is intended for seed production should be grown on clean land, free from such objectionable weeds as dock (*Rumex*), catchfly (*Silene stellata*), foxtail (*Setaria*), black medick (*Medicago lupulina*), bladder campion (*Silene inflata*), wild mustard (*Brassica arvensis*), white cockle (*Lychnis vespertina*), and ragweed (*Ambrosia*). Seeds of some of these weeds are particularly difficult to remove in cleaning, and therefore they reduce the grade. Fields of red clover seed which are otherwise eligible for certification must be rogued from certain of these weeds before they can pass inspection.

Note on Production of Red Clover Seed in U.S.A.

A. J. PIETERS.

THE agronomic features of the production of red clover in the United States are substantially as described by L. E. Kirk and R. MacVicar for Canada. A few points should be noted as of special reference to the production of these crops in the United States. Information in regard to quantities produced and yields per acre is given in a general article upon the production of seeds of herbage plants in the United States to be published in a later Bulletin in this Series.

Throughout the main red clover belt in U.S.A. the seed crop is incidental to the hay crop and the second crop may be cut for seed or not, as seems likely to be profitable. In certain sections, however, as in the irrigated regions of the Rocky Mountain States, red clover is grown for seed production only. In these sections it is not uncommon to cut two crops of seed in one season, making, of course, for very large yields of seed per acre. In the irrigated sections of Idaho and eastern Oregon the seed crop is also the main consideration. While a hay crop may be cut, this is taken so as to leave the crop in good shape for seed production. In the Willamette Valley of Oregon the crop is often cut at night or very early in the morning in order to avoid the intensive drying which occurs during the day and which is likely to result in a great deal of shattering.

White Clover (*Trifolium repens*)

J. E. HOSKING

England

BRITISH agriculture recognises two types of *Trifolium repens*, the cultivated Dutch white type and the wild or indigenous type. The former has a larger leaf, is earlier

in flowering, less dense and less prostrate in habit. Within these two groups there are wide variations in size and habit, particularly in the indigenous types. These variations are sufficiently marked for a number of strains to be recognized in commerce, the strain name being usually that of the district in which the seed is produced.

White clover may be found growing on a wide range of soils and in most districts in the British Isles, but it does best on fertile loams well supplied with lime. Seed production on a commercial scale is confined to districts with a rainfall of 20 to 28 inches in the southern half of England.

PLACE IN ROTATION.

The cultivated types usually follow barley or oats, the seed being sown among one or other of these cereals, which acts as a nurse crop; the seed is sometimes sown without a nurse crop. Seed of wild white clover is harvested from permanent pastures, some of which have been down for a great number of years, while others are at least ten years old and originated from seed collected from other old pastures.

METHOD OF SOWING.

Cultivated white clover is sown at a rate of 8 to 15 lb. per acre, but wild white clover is generally sown at 6 to 9 lb. per acre in mixtures with grasses such as indigenous ryegrass (*Lolium perenne*) and crested dogtail (*Cynosurus cristatus*). The seed is generally sown broadcast. A lower rate of seeding is frequently used, but this is not recommended by those with the greatest experience in producing an even sward. April and May are the months most favoured for sowing the seed in a nurse crop, but the early autumn months are more suitable for sowing without a nurse crop. The crop must be well rolled in autumn and spring.

FERTILIZERS.

Phosphatic fertilizers are the most favoured for white clover and of these basic slag is most common, 5 to 10 cwt. per acre being applied in autumn or late winter. Lime is rarely used, but it gives excellent results when applied to land in which it is deficient. The fertilizer for the cultivated white clover is usually applied to the nurse crop and not direct to the white clover crop. Again phosphates are favoured, either superphosphate at rates up to 5 cwt. per acre or basic slag from 5 to 10 cwt. per acre.

GRAZING.

The best custom is to commence hard grazing as early as possible in spring, preferably by sheep, and to continue until the first or second week in June. The animals are then taken off and the crop allowed to flower for production of seed. The latest date, in practice, for removing the live stock is about the end of the third week in June; this refers particularly to wild white clover, but we have records of crops of seed being taken in the autumn in abnormal seasons. The cultivated white clover is frequently closed for seed two to three weeks earlier than the wild white clover. Some growers prefer mowing to grazing before the field is finally closed for seed, but on the whole grazing seems to be the most satisfactory method.

ISOLATION.

As it is rare that any other white clover seed is grown in the old established wild white clover seed producing districts, the danger of cross-pollination does not arise.

Where Dutch white clover is grown near wild white clover it is not usual to save both for seed in the same season. One is either mown or grazed to prevent flowering, although there is actually no very real danger, as it is unusual for both types to flower at the same time. Some late flowers in the Dutch white type and some early flowers in the wild white type might be cross-pollinated, but these would not be mature when the crop was harvested as a Dutch white crop. In a wild white clover crop these flowering heads would be over-ripe and would sink below the cutter bar when the seed is cut, or if the seeds produced did find their way into the seed crop they would probably be larger and discoloured and could be removed by the seed cleaning plant.

HARVESTING.

The cultivated Dutch white clover is harvested for seed during the latter part of July and the wild white clover during August. The crop is ready for cutting when the heads are brown and reflexed and the stalk beneath the florets has turned a straw colour. There should be 80 to 90 per cent of the heads showing these signs when the crop is ripe for cutting. Bright yellow seeds can be rubbed from the heads by hand at this stage.

The crop is cut with a mowing machine and left in swathes. When the heads are close to the ground a sack or metal tray is attached to the cutter bar to catch the heads which are then raked off from behind into heaps. The crop is turned gently a number of times to ensure dryness and thorough airing.

The compactness of the florets within the heads and the elasticity of the pods prevent the seeds from shedding. The length of time for field conditioning depends upon the degree of maturity of the crop when cut and the weather conditions, but from three to nine days is an average. Occasionally, if the weather conditions are favourable and the crop is well turned, threshing takes place in the field, but the usual method is to build small stacks—small to avoid heating—which are threshed as soon as possible. A practical stack for maturing the seed should be 8 to 10 yards by 3 to 5 yards, the narrow width being used when the crop is not absolutely dry. The width and height are more important than the length. The seed can then be threshed at the grower's convenience any time from August to the following March.

YIELD.

The amount of seed produced per acre varies a great deal, from 180 to 260 lb. for the Dutch white type and from 40 to 100 lb. for the wild white type. Many experienced growers of wild white clover introduce hives of bees near the crops and are confident that an increased yield of seed results.

Two remunerative crops at least can be taken from the cultivated white clover, but with wild white clover no definite number of crops can be recommended, as so much depends on the management of the pasture, the situation and the manurial treatment. Even where it is possible to take successive crops of seed, it is usually considered to be a better practice to take seed in alternate years.

DISEASES AND PESTS.

Trifolium repens is not seriously attacked by fungous diseases and insect pests, although it may occasionally be damaged by the clover stem eelworm (*Anguillulina dipsaci*), *Apion* and *Sclerotinia*. At present the only practical method of controlling *Sclerotinia* is to exclude legumes from the crop rotation for a number of years.

White Clover (*Trifolium repens*)

GEORGE WOOD

England
(Cotswolds)

THE pioneer of the wild white clover seed production industry in this part of the country was George Wood (senior) of Haselton. He was a native of the Tyne valley, who moved from Thornborough to Haselton in 1906. Wages on the Cotswolds were then only half of those in Northumbria, but the low output per man actually made the work more expensive. In 1911 he extended his farming to the limit of his resources by purchasing the Priory Farm of 740 acres. He had abandoned the use of the plough after five years of arable farming on the stiff shallow Haselton land, and he found his new farm in a condition typical of the district after years with derelict walls, the four-course rotation and a diminutive flock of large Oxford or Cotswold ewes.

Half a hundredweight of white wild clover seed was broadcast on the dirtiest wheat stubble in the autumn of 1911, the mixture being made up as follows (in pounds per acre): wild white 2; timothy 4; cocksfoot 6; Pacey's perennial ryegrass 12 (the Cockle Park mixture). Half was sown in the autumn and half in the following spring, a good dressing of basic slag being applied. In later years timothy was discarded, being so difficult to separate from wild white clover. The success of this mixture was astonishing and the field can be seen to this day.

Mr. Wood continued to lay down his own farm to permanent grass and to build up the walls. The self-supporting Cheviots and prolific Half-breds which he introduced to the district did exceedingly well on this young grass.

It was suggested to the owner that a seed crop should be taken; the sheep were immediately taken out and in due course the seed was harvested, threshed and sold at about three shillings and sixpence per pound. A Ruston clover huller and an Overtime tractor were purchased later.

Although figures of acreages, yields and prices obtained at Haselton are not now available, it will be realized that rapid expansion, coinciding as it did with the war-time inflation and the spread of the knowledge of the value of wild white clover by Somerville and Gilchrist, was remarkably remunerative and opportune. Appreciation of the value of wild white clover enabled the owner to avoid ploughing up more than 400 acres of pastures (out of 1,000 acres) during the war-time wheat-growing campaign of 1917 to 1918.

As the extra value of seed from old pastures became more and more evident, the old "tumble-downs" at Haselton received more attention and by heavy winter grazing and applications of slag the indigenous wild white clover which was present was induced to flourish as never before. The highest price reached by dressed seed from Haselton was thirty shillings per pound in 1920.

A dosser was installed and the seed was never offered to the trade at less than 95 per cent purity. During those times it was profitable to thresh the crop twice, as it could be put through almost twice as rapidly at the second threshing. If four pounds of seed were obtained from a ton of threshed hay it was the invariable practice to do so. Seed from the second threshing always seemed to be a better sample. When the crop was very short and full of seed it was mown with a scythe.

As the age of wild white clover pastures increases and the fertility of the soil rises it becomes more and more difficult to keep the grasses in check and the yield of seed tends to decrease as the age of the plant increases. With the price of wild white clover rapidly falling and grass-fed beef becoming more difficult to sell, little seed has been produced on the Priory Farm since the 1929 crop.

Mr. Wood took an active interest in the Ministry of Agriculture's Certification Scheme, and the policy of not introducing white clover seed of any description has been scrupulously followed on these farms.

Production of seed was commenced on the Glebe Farm, Haselton, in 1929. The

Particulars are given below of grass closed for seed, acres harvested, yield per acre and price per pound for the years 1930 to date :

Year.	Acres farmed.	Acres certified	Acres closed for seed.	Acres har- vested.	Yield in lb. per acre.	Price s. d.	Percent- age purity.	Percent- age germina- tion.	Percent- age hard seed.
1930	281	—	58	29	27	3.1½	94	83	12
1931	279	42	73	nil	nil	—	—	—	—
1932	279	114	111	20	1.5	—	92	72	11
1933	279	132	52	18	43	2.9	97	83	15
1934	279	122	60	26	20	3.2	97.8	69	28
1935	277	122	65	44	31	3.0	98.2	85	13
1936	555	96	81	nil	—	—	—	—	—
Seven year average			73	20	25	3.0 (approx).			
Grass average return per acre				£3 15 0.					

The decrease in the area of the farm is due to tree planting. The decrease in the area certified is due to the ploughing up of certified pastures to grow wheat. This means that these fields will not be available for the production of grade "A" seed for at least fourteen years. The yields per acre and the price per pound explain the necessity for this decrease of certified area.

It would be interesting to have similar figures from a grower of grade "B" seed, as well as from a grower of ungraded seed for the same period. The outlook for grade "A" producers is very hopeful at the moment, if only from the fact that they must surely be looking upwards from the bottom of the pit. From the horizontal point of view it is unlikely that many recruits will offer their services, even if prices are doubled and remain at that figure for some years.

White clover (*Trifolium repens*)

F. CHMELÁŘ

Czechoslovakia

Trifolium repens is grown for seed on an area of about 3,000 ha. (1935 = 3,216 ha.) in Czechoslovakia. Most of this area (1,924 ha. in 1935) is in the cereal-potato region and in the cereal region (938 ha.). (See *Herb. Publ. Ser. Bull.* 15.) The main centre of its cultivation is on the Czecho-Moravian highland (Českomoravská vysočina) where it is cultivated on light, sandy podsols at an elevation of about 300 to 500 m. and in an annual rainfall of 600 to 800 mm. Similar conditions occur in a smaller centre in southern Bohemia. In another centre in northern Bohemia, the climate is more humid (over 800 mm. annual rainfall) and the soil is a Permian red podsol. In Slovakia white clover seed production is commencing in districts on trachite and andesite brown soils at an approximate elevation of 200 m. with an annual rainfall of 600 to 800 mm. (A map of these areas will appear in a later Bulletin in *Herb. Publ. Series*.)

According to the State Statistical Office, the average yield for the entire State is rather low. In 1935, an average year, it was 240 kg. per ha. This is, however, because the fields are used for forage and only when the growth is becoming sparse is a seed crop taken. Under proper care yields vary from 5 to 8 q. per ha. The total harvest of 7,821 q. in 1935 had a value of about 5.5 million Kč. (at a price of 700 Kč. per 100 kg. seed.)

The best white clover seed crops are produced in humid highland on light podsol soil. The species is usually sown with oats as a nurse crop at a rate of 7 to 10 kg. per ha. and is used for one year only, the seed being harvested from the first cut, after which the stubble is turned under and the field prepared for a winter cereal. If too dense and luxuriant in spring and in order to prevent weeds from forming seeds, the crop is cut once before leaving for seed; this is done before the plant forms flower heads, as otherwise few blossoms are developed in the subsequent growth. Under favourable conditions and if sufficient amounts of potash and phosphoric acid are added, it may remain for another year's use. Harvesting is done very carefully, as the danger of seed loss through breaking of entire heads is considerable. Threshing is easier than with red clover and is often done on the field. Shelling and cleaning are carried out on special machines; the latter operation is particularly difficult if dodder is present. Great care must, therefore, be taken that no dodder plants appear on the seed field; hybrid clover must also be rogued out as its seed cannot be separated from white clover seed.

Breeding work has recently begun, but no special varieties or strains are yet grown. The cultivated local strains are very hardy, healthy and productive. Therefore their seed is esteemed abroad and is exported principally to Germany, Great

Britain, France, etc. In 1935, 3,590 q. were exported. Two types of Czechoslovakian white clover have long been distinguished, namely, Bohemian and Moravian.

Subterranean Clover
(*Trifolium subterraneum*)

B. T. DICKSON

Australia

HISTORICAL NOTE.

This plant, which has revolutionized farming practices in better rainfall areas of southern Australia, converted large areas of virgin land into highly productive pastures, and re-established the fertility of land previously thought worn-out, seems to have existed on several farms in the Mount Barker district of South Australia in the very early days of settlement. It was to an Englishman, Mr. Amos William Howard, who settled at "Beauvale", Elakiston, South Australia, in 1889, that the credit is due for first directing attention to the worth of subterranean clover. He consistently and strongly advocated its use, and in 1900 the first attempts to harvest seed were made on his farm. Freeing the seed from the pods was difficult, but by hand rubbing and the use of sieves some clean seed was obtained and small quantities sold in 1903 at 2s. per pound. The first commercial sale appears to have been made to Messrs. E. and W. Hackett and Co. of Adelaide in 1906, when 30 lb. were delivered at 2s. 6d. per lb. In 1916-17, five cwt. were harvested in South Australia from ten acres and by 1934-5 the harvest had reached 4,792 cwt. from 1,768 acres. In the year 1930, when Mr. Howard died, there was a record yield of 5,082 cwt. from 1,736 acres in his adopted State, so that he lived to see the fruits of his efforts. From hand treatment of the seed there have been progressive developments to the use to-day of revolving brooms drawn by horses to collect the seed, and threshing and cleaning machines with a capacity up to 35 cwt. of clean seed per diem.

CULTURE.

Subterranean clover is able to grow well in most types of soil, given sufficient phosphoric acid, a rainfall of 16 to 40 inches and a growing season of about eight months before the onset of really hot, dry summer weather, although it gives best returns in a fertile, well-drained loam. Usually stiff, heavy soils and "crab-hole" land are avoided and flat undulating country is preferred for seed production, because of greater facility in harvesting seed. It is obvious that land which hardens or cakes will not be satisfactory for harvesting seed. Topdressing with superphosphate is essential for the satisfactory production of subterranean clover; the fertilizer is applied at the rate of 1 cwt. per acre per year, and where the rainfall is 25 inches or more up to 2 cwt. per acre.

Where the clover has become established seed germinates with the early autumn rains, makes good root growth but not much top before winter, and then with the warm spring weather develops a luxuriant stand. Therefore, when a new area is to be sown the land should be prepared beforehand for a good seedbed, and the seed planted while the soil is still warm and when the autumn rains are sufficient to ensure good germination. Shallow seeding (about 0.5 inch) is essential.

Good crops are often obtained from virgin country, but usually fields selected for harvest are the result of careful nursing over several years, beginning with the sowing of about 4 lb. of seed with a cover crop of oats, which is ultimately cut for hay. The seed is mixed with fertilizer and sown through the manure box of a drill, while the cover crop is sown through the grain box. The oat stubble is topdressed during the following autumn at 1 cwt. per acre, and a fair stand of clover usually develops.

This is lightly grazed during the season and again topdressed in autumn, while the seed crop is produced during the following summer. Grazing is usually stopped in September in the years of harvest, although it may be allowed in some districts until the period of early ripening if growth is rank.

HARVESTING AND THRESHING.

Harvesting the seed is an operation which has been evolved in Australia; while in some parts the surface growth when dry is burned off with a quick fire and in others it is mown for hay, the fact that much of the seed is buried in the soil necessitates the employment of special rakes and brooms or rollers. In Western Australia pasture harrows are drawn over the ground to break the top layer and render burr collection easier. This is done by using a drum or roller covered with a sheep skin carrying a staple of 1 to 1.5 inches which is drawn over the ground, the burrs so collected being brushed off by a revolving brush into a box underneath; at the same time the brush teases the wool so that it continues to pick up burrs. Depots in the paddock receive the collected burrs; there they are roughly cleaned on wire screens and passed between heavy wire-covered jarrah rollers on a dehulling machine. By means of an air current the seed is winnowed and collected in bags. It is then put through a grader; that which has a purity of 96 to 97 per cent is known as First Grade Seed, while lighter seed is sold as F.A.Q. grade.

In other parts the paddock is raked after the top straw has been removed, by a close-tined heavy rake. The tines are about 1.5 in. wide at the tip and so arranged that they overlap and function as a "rake-grader." The material is raked into windrows and then carted, stacked and covered with a tarpaulin until threshing can be done. The burrs still lying on the surface are usually gathered with a revolving horse broom or even with a road grader. These sweepings usually contain most seed and are threshed first.

As in Victoria harvesting of subterranean clover seed was first undertaken where tufted grasses like perennial ryegrass were growing, raking and sweeping could not so easily be practised. There the crop is harvested like a hay crop, although at a later stage of maturity, and it is then put through a peg drum thresher to separate burr from straw. The auto-header is used in those cases where the swath is lifted to the threshing drum of a moving harvester, but yields are comparatively light with this procedure.

As a result of many years of trial, special threshing machines have been developed in South Australia, whereby all debris is first removed; the clover burrs are then separated from the straw in a peg drum and conveyed to a huller and grader which shell and clean the seed. Some of these machines are now in use in Victoria and Tasmania.

STRAINS.

In Western Australia it has been possible to determine certain apparently well-marked types not only by reason of differing times of maturation, but also by calyx and leaf characters. Thus, there are the Dwalganup or First Early, the Daliak, the Northern Early and the Midseason strains, and the Brunswick Late variety. The Dwalganup strain commences to flower early in August, is very hardy and suitable for areas of lighter rainfall. The Midseason strain is the one most commonly cultivated in the lower southwest of Western Australia. It is more prolific and flowers from mid-September. The Brunswick Late variety, or Weginup clover, as it is often called, first appeared near Bridgetown, but nothing is reliably known of its origin. It produces the greatest bulk of feed, flowers in late October and early November, and is suitable only for higher rainfall areas.

The early types bury most of their seeds, but the Midseason strain and Brunswick variety bury only a proportion.

In South Australia the main strain is the Mount Barker, which is a midseason, leafy plant flowering about the third week of September.

In Victoria three strains are harvested for seed—the Dwalganup, Mount Barker and Tallarook. The last is late in flowering (2nd week of October), leafy and suitable for the better rainfall areas of the State.

While burial of seed is characteristic and all strains attempt to bury seed, with greater success in the case of early than of late strains, other factors may affect the phenomenon. If the season is dry and the soil hard, fewer seeds will be buried and they will be buried less deeply. Prolific growth may prevent the uppermost flower stalks from reaching the soil.

Strawberry Clover (*Trifolium fragiferum*)

B. T. DICKSON

Australia

Strawberry clover is limited to districts with a good rainfall—30 inches or more—as for example in central and southern Victoria and coastal areas of Western Australia.

It prefers heavy black soils such as occur along streams where the moisture remains at depth in summer, a condition suited to this deep-rooting species. It is used in irrigated pastures, particularly where the soil has a high salt content. Such soils do not lend themselves so readily to cultivation; consequently it is more customary to propagate the crop by planting runners about 1 foot apart in spring. If seed is used, it is sown at the rate of 2 lb. per acre either in early autumn or spring.

Topdressing with superphosphate is necessary at the rate of about 1 cwt. per acre per year in order to obtain profitable results, and a satisfactory stand usually develops in about five years from planting.

For the production of seed the crop is grazed fairly heavily until the middle of spring, after which the paddock is closed. Flowering commences in January as a rule and the seed is mature during the summer heat of February, which is usually also a dry period. If rain falls, ripening tends to be uneven because the flowering period is extended.

Strawberry clover bears the ripe seed heads well above ground, thus permitting the crop to be mown; as the seed is tightly held it can be cured in the field and stacked for a considerable period. It is threshed to remove the heads from the straw; they are passed through a huller such as is used for subterranean clover, after which the seed is cleaned and graded.

There is only a small trade in this clover. While it is known that local strains exist, they have not yet been recognized in practice.

Crimson Clover
(*Trifolium incarnatum*)

F. CHMELÁŘ

Czechoslovakia

The total area on which *Trifolium incarnatum* is grown for seed in Czechoslovakia was 1,155 ha. in 1935, which is approximately an average figure. Most of the crop was grown in the sugar-beet region (658 ha.), less in the cereal region (307 ha.). The main centre of crimson clover seed production is in eastern and central Bohemia, in the warm and rich valley of Labe at an elevation of 200 to 300 m. with an annual rainfall of 600 to 700 mm. on alluvial, sandy soil or middle-European brown soil. On the Czecho-Moravian highland, especially on its Moravian side, crimson clover is cultivated on podsoles at a higher elevation (400 to 600 m.) and in more humid conditions (600 to 800 mm. rainfall). In western Slovakia small amounts of this seed are produced near Malacky in a rather dry region (500 to 600 mm. annual precipitation) at an elevation of 100 to 200 m. on alluvial sands in a continental climate. (See map in a later Bulletin in the *Herb. Publ. Series*.)

According to the State Statistical Office, the average yield of seed per ha. is 350 kg. (1935 = 320 kg.). The highest yields are recorded in the sugar-beet region in Bohemia (average up to 500 kg. in 1935). A good growth furnishes 6 to 10 q. seed and 20 to 25 q. straw per ha. In the whole Republic 3,712 q. of crimson clover seed were harvested in 1935, representing a value over 1 million Kč. (at the price of about 300 Kč. per q.).

Although the breeding of crimson clover was started some time ago, no special varieties have yet been marketed. Old local strains prove very satisfactory both with respect to their vigour and productivity. In addition, they are very drought and frost resistant, a fact which has also been recognized abroad; Bohemian crimson clover seed is exported, especially to Germany.

Crimson clover for seed is usually sown in August without any nurse crop, because it grows very rapidly and would be shaded by the nurse crop. About 14 to 28 kg. seed are required to drill one hectare in rows 12 to 20 cm. apart. In favourable conditions the crop furnishes one cut in the autumn. In the following spring the first cut is left for seed. The plant blossoms in May or at the beginning of June and ripens in July or August. The seed is easily shed from ripe heads, which may also fall if too dry. The correct moment for harvesting is therefore important. The crop should be cut when the seeds of the lower flowers of the heads are fully coloured. The plants are moved as little as possible while drying. This is done usually on the ground or on stands, loose or in bundles (small sheaves). The ripe seed may be shaken over a canvas before bundling and drying. The threshing and dressing of seed are easier than with other clovers, but still require some care and practice in order not to break the rather large seeds.

Alsike **L. E. KIRK and R. MacVICAR**
(*Trifolium hybridum*)

Canada

The alsike seed-growing areas are located chiefly in Ontario and in districts where the soil and moisture conditions enable this crop to displace red clover, a crop which is generally highly adapted to eastern Canadian conditions. Soils which have a tendency towards acidity and have relatively poor drainage provide an environment more suitable to alsike than to red clover.

Thorough soil preparation is considered an absolute necessity in alsike seed production, and it has been found preferable to have an intertilled crop on the land the year previous to the seeding of alsike. The usual practice is to sow the alsike with a nurse crop of wheat, oats or barley. Occasionally the seed is broadcast on winter wheat in the spring of the year. The rate of seeding varies in accordance with the experiences of the various growers, but 8 to 10 lb. of seed per acre is considered to be ample. Broadcast seeding is practised by means of a grass seed attachment on the grain drill. Some producers favour hand seeders, claiming that better stands can be obtained in this way.

Good stands are the "rule," and unsatisfactory ones are usually the result of poor seed-bed preparation, or unfavourable moisture or temperature conditions during the growing season. Fine seed-bed preparation and early seeding minimize the effect of hot and dry midsummer conditions. When seeding is too long delayed, the clover plants have not sufficient time properly to establish themselves before hot weather sets in, with the result that the competition of the rapidly growing grain crop is detrimental. Generally, the seedlings do not attain much size until after the grain crop is harvested, but from that time until late autumn growth is rapid.

Light, early spring grazing in the second year of growth is considered by some growers to be a desirable means of obtaining uniformity of maturity and a somewhat heavier yield of seed. Fertilization of alsike fields is not generally practised, although experience has shown that a dressing of acid phosphate results in increased yields.

Alsike is usually ready to harvest for seed from the latter part of July to early August, depending on seasonal conditions. The crop is considered ready for harvest when the heads have turned a dark brown. Some growers harvest the seed when it is in the dough stage, claiming that less shattering occurs and a finer grade of seed results from this practice.

A hay mower is generally used for cutting the crop. It is usually equipped with a "buncher" attachment of some kind which will collect the crop in bunches or deliver it in windrows behind the machine. Occasionally a selfrake reaper is used. When the crop is particularly heavy, a pea-vine lifter attachment on the cutting bar of the mower works to advantage. With careful handling seed shattering can be largely avoided. It is the practice to cut in the morning while the plants are still moist with dew. The material is then left in windrows or in bunches to cure and is not disturbed, if conditions are favourable for drying, until it is to be threshed.

Field threshing is the rule, but it is sometimes necessary, due to weather conditions or scarcity of threshing mills, to place the crop in stacks or in hay mows for threshing at a more convenient time.

The ordinary grain separator equipped for clover threshing is commonly used. Excellent results are obtained if the crop is well cured and the machine is carefully adjusted. Clover hullers designed for handling the various clovers are also available and are used to some extent.

Yields of alsike seed vary greatly from season to season, depending on such factors as the stand of plants, climatic conditions and the prevalence of pollinating insects. Yields are obtained ranging from 100 to 500 lb. per acre, the latter being not uncommon. A yield of about 250 lb. per acre is considered to be a good crop.

While it is sometimes possible to secure seed crops on clean productive land for two or three successive seasons, one remunerative crop is all that can be expected as a rule. The chief difficulty is the encroachment of weeds which makes the production of clean seed impossible.

The prevalence of certain noxious weeds such as night flowering catchfly (*Silene*

nociflora), white campion (*Lychnis vespertina*), dock (*Rumex*), Canada thistle (*Cirsium arvense*) and similar weeds is one of the main drawbacks to the profitable production of alsike seed. Night flowering catchfly is especially objectionable, since the seed is similar in size and colour to that of alsike. As it is very difficult to produce alsike seed of high quality on land which has become polluted with such weeds, the best success with this crop is always obtained on land which has come under the plough in relatively recent years, or where a crop rotation is definitely planned to provide clean land for the production of alsike seed.

Note on Production of Alsike Clover Seed in U.S.A.

A. J. PIETERS.

The agronomic features of the production of alsike clover in the United States are substantially as described by L. E. Kirk and R. MacVicar for Canada. A few points should be noted as of special reference to the production of these crops in the United States. Information in regard to quantities produced and yields per acre is given in a general article upon the production of seeds of herbage plants in the United States to be published in a later Bulletin in this Series.

Alsike clover seed is produced mainly in the Great Lakes region and in the irrigated sections of southern Idaho. There is also a considerable production in the Willamette Valley of Oregon. Threshing is more commonly done by regular clover hullers than by threshing machines with clover hulling attachments, although both are used. In some places it has been found advantageous to place colonies of honey bees in the alsike fields, as this results in a material increase in the yield of seed. Alsike clover is especially adapted to this procedure as the bees can readily secure the nectar which they are not able to obtain from red clover. The straw from alsike clover is not infrequently put through the threshing machine a second time and sufficient seed is recovered to compensate for the extra cost of this operation.

Berseem
(*Trifolium alexandrinum*)

WYNNE SAYER

India

Berseem is now extensively grown in India as a cold weather green fodder crop. Unlike other crops which are grown without irrigation in North Bihar, berseem requires frequent irrigations, and in fact cannot be grown without water.

SOIL.

Berseem is grown successfully both on high and low lands and in light and heavy soils. If the field has not carried berseem before, it is necessary to inoculate with berseem soil from some other place; special cultures are obtainable from Lyallpur.

PREPARATION OF THE FIELD.

Before sowing, the land is thoroughly ploughed to a depth of 5 to 7 inches, and subsequent cultivations are given with a light cultivator in order to remove all traces of weeds and grasses. The field is then properly levelled, and bunds are erected on all sides to facilitate irrigation.

SOWING.

The best time of sowing is at the change between the hot and the beginning of the cold seasons when the night temperature is about 65°F. At Pusa, sowing starts from the beginning of October and is continued up to the end of November. About 25 to 30 lb. seed per acre can be sown. The seed should be steeped for 12 hours in fresh water before sowing. After irrigating the ploughed land to a depth of 2 to 3 inches, the seed is sown broadcast—once across the field and again at right angles. The irrigation water should not be allowed to stand on the plot for more than 24 hours after sowing, the excess water being drained out after this interval.

SUBSEQUENT IRRIGATION.

The amount of water required and the number of irrigations to be given depend solely upon the local conditions. At Pusa, in light soil, it is necessary to irrigate the crop once a week, and in heavy soil, the irrigation may be fortnightly. The amount of water given each time is about 1 to 2 inches deep, i.e. about 100 to 200 tons per acre. It is also necessary to irrigate the plot once after each cutting or grazing.

CUTTING BERSEEM FOR GREEN FODDER.

The first crop becomes ready for cutting in about 40 to 50 days after sowing, when the plant is about 1 foot high. Three subsequent cuttings are generally taken at intervals of 6 weeks. If the crop is grazed, it is desirable to cut the portions left by animals in the course of grazing and spread the dung uniformly over the entire area, before an irrigation is given.

The average yield of green fodder at Pusa is about 90 maunds per acre per cut. (The standard maund in India is equivalent in British imperial weight to approximately 82 lb.)

FEEDING OF BERSEEM.

For feeding the milch herd, it is convenient to divide the whole area into 0.25 acre plots and cut the crop in rotation to ensure a continuous supply of green fodder from December to May. For grazing, it is desirable to introduce the milch cows first, followed by dry stock, in order that the field may be evenly grazed.

SETTING OF SEED.

Though berseem has been grown on a large scale at Pusa for a number of years, it has not been possible to obtain seed successfully in large quantities. The crop has been set aside for seed after the third cutting, and possibly this may be too late for the district. Further experiments will be conducted in Delhi.

Berseem seed has been produced on almost all the Government Farms in the Punjab Province. The number of cuttings to be taken before the crop is left for seed depends on the fertility of the soil. In rich and comparatively poor soils the crop is left for seed after three and two cuttings respectively. The last cut should be completed by the first week of March, and in rich soil not later than the middle of the same month. In order to obtain the best quality seed even at the expense of fodder, mid-February is the most suitable time to leave the crop to set seed. The crop is liable to lodge at flowering time; if this occurs during seed formation it will produce non-uniform seed. Waterings should cease during the fertilization period, but frequent irrigations should be given after the seed is set to obtain good results.

The crop shows brown heads when ripe. Harvesting is done early in the morning and the crop is removed to the threshing floor for thorough drying. Threshing is done by treading with bullocks over the dry material.

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Sweet Clover
(*Melilotus* species)

L. E. KIRK and
T. M. STEVENSON

Canada

The production of sweet clover as a cultivated crop in Canada is confined chiefly to the prairie provinces, particularly those areas which are not favoured with an abundant supply of soil moisture. A considerable acreage is grown also in Ontario, more especially southwestern Ontario. This plant is adapted to a wide range of soil and climatic conditions, thriving on most types of non-acid soil and on soils containing relatively high concentrations of alkali salts. The better varieties do not winter-kill even under severe conditions. As a dry land crop, sweet clover excels in the production of pasture and hay. It possesses remarkable soil improving qualities and is favoured for bee pasture.

Numerous varieties are available, belonging chiefly to *M. albus*, a white blossom biennial type, and to *M. officinalis*, a biennial yellow blossom type. The white blossom variety, Arctic, is widely used in western Canada.

Where lack of soil moisture is the chief limiting factor, highest seed yields are obtained from seedings made on land which had been summer-fallowed, or following an intertilled crop. Under more favourable moisture conditions, satisfactory results are obtained from sowing on clean stubble land. There is no general rule regarding the preparation of the seed bed, except that the land must be reasonably firm. A seed bed left in a loose, open condition dries out quickly and rarely produces a satisfactory stand.

The general practice is to sow the sweet clover with a light nurse crop of wheat, oats, or barley; the nurse crop is often harvested while immature and used for hay. Seedings made in drills spaced 6 inches apart or broadcast are preferred. In the drier areas of western Canada, however, higher seed yields are obtained from seeding in rows spaced about 3 feet apart. When sown in closely spaced drills with a nurse crop, many growers prefer to sow the cereal first, followed by the sweet clover. This method has the advantage of permitting both the cereal and the clover seeds to be sown to the depth most suitable for each. Young seedlings of sweet clover will rarely emerge through more than one inch of soil, whereas the cereals are generally sown to a depth of 2 or 3 inches.

From 15 to 18 lb. of seed are required per acre when sown broadcast or in drills spaced 6 inches apart. When sown in widely spaced rows, from 4 to 5 lb. of seed per acre are sufficient.

The seeds of most species of *Melilotus* possess impermeable seed coats and some treatment prior to seeding is necessary to render them permeable to moisture. The usual method is to scarify the seeds by means of a machine which blows them forcibly against a surface covered with emery or sandpaper.

During the year of seeding, weeds are controlled by use of the mowing machine

and the cultivator. Light autumn grazing is practised, but if begun before late September it is likely to result in decreased yields of clover in the following year.

The crop is harvested when one-half to three-quarters of the seeds are mature. All the seeds do not ripen at the same time and it frequently happens that ripe pods are being shed from the lower parts of the branches while flowers are still being produced at their tips. The general practice is to begin to harvest the crop just as soon as there is any evidence of seeds being shed. The crop is harvested by means of the grain binder, and the sheaves are set up in stooks of a type which permits rapid curing.

During the harvesting process many of the mature pods may drop off the plants. Much seed is sometimes lost in this manner, especially when dry, bright weather prevails during harvest time. By use of a box attachment, which fits beneath the space between the table and elevator canvasses, much loss of seed can be prevented. Loss is also avoided through harvesting the crop during the early morning when there is less tendency for the seeds to fall due to a slight dampness on the plants.

Under favourable weather conditions the crop can be threshed after being in stook for from ten to twenty days. The yield of dressed seed from sweet clover ranges from 150 to 600 lb. per acre.

The ordinary grain thresher is commonly employed for threshing sweet clover. If the plants are not too coarse, the concaves may be set as for wheat, in which case the seed will be more or less hulled at the same operation. If the plants are very large, it is advisable to remove some of the concaves and leave the cylinder teeth wide open, thus permitting the stalks to pass through readily. By replacing the concaves, closing up the cylinder, and putting the pods through a second and third time, the separator may be made to do the work of a huller. This also increases the percentage of permeable seed.

Weed seed can be separated from sweet clover more easily before the seed is hulled and many seed companies prefer to purchase it in the pod. They can then clean it first and hull it afterwards. If many weed seeds are present, it is a good plan not to hull the seed in threshing.

During years of severe outbreaks of cutworms entire stands of sweet clover may be destroyed shortly after the seedlings emerge. Occasionally these pests attack the plants in the early spring of the second year, but rarely cause great damage. The red-backed cutworm (*Euxoa ochrogaster*) is controlled chiefly through proper cultivation during the summerfallow year and through the use of poison bait when the caterpillars are active. The pale western cutworm can be controlled only through cultivation. Damage is often avoided by delaying seeding until danger of severe damage is past.

The sweet clover crop is rarely damaged seriously by disease. Occasionally stands of certain varieties are thinned out considerably by root-rot caused by *Plenodomus meliloti* during the early spring of the second year.

Note on Production of Sweet Clover Seed in U.S.A.

A. J. PIETERS.

The agronomic features of the production of sweet clover in the United States are substantially as described by L. E. Kirk and T. M. Stevenson for Canada. A few points should be noted as of special reference to the production of these crops in the United States. Information in regard to quantities produced and yields per acre is given in a general article upon the production of seeds of herbage plants in the United States to be published in a later Bulletin in this Series.

As indicated by Kirk and Stevenson, the production of sweet clover seed is more common in the west than in the east. In the United States, however, rather large quantities are produced as far east as Ohio. Considerable quantities are also harvested, especially in years when the seed is relatively high, upon the banks of irrigation ditches throughout the irrigated sections of the west. In such sections sweet clover has become established as a weed and the seed is, of course, taken as an incidental crop. In Illinois and certain other sections, many farmers harvest seed with beaters which knock the seed off from the standing plants and leave the plants on the field. In any event, there is a very heavy loss of seed, but harvesting by means of a beater is believed to be more economical and results in a smaller cost per pound for the harvesting operation. These beaters are commonly made by the farmers themselves out of material of old binders readjusted with arms which serve to beat the seed from the plants. The practice of sowing unhulled and unscarified seed in autumn and winter appears to be upon the increase. It has been found that reasonable stands can be secured in this way and the extra expense of hulling and scarifying is avoided.

Diseases of sweet clover appear to be perhaps more prominent in the eastern United States than they are in Canada. Several diseases, especially mosaic, stem and crown rots and others, often make heavy inroads into the stands of plants or materially reduce the vigour. In the Willamette Valley of Oregon a form of stem-rot, possibly due to *Sclerotinia trifoliorum*, is extremely serious. A sweet clover strain has been selected which is highly resistant to this disease and seed of this strain is now being harvested in Oregon.

Lupins (*Lupinus* species)

R. von SENGBUSCH

Germany

The lupin species most commonly grown in Germany are *Lupinus luteus* and *L. angustifolius*; the cultivation of *Lupinus albus* has not become established until quite recently. Until a few years ago, only bitter forms of these three lupins were in existence. After the discovery of alkaloid-free mutants in the three species mentioned, and with the increasing reproduction of the alkaloid-free "sweet lupin" material, a displacement of bitter lupin cultivation in favour of that of sweet lupins has taken place. It is probable that by 1938 the whole lupin area in Germany will be planted with sweet lupins.

Hitherto lupins in their natural state were used exclusively for feeding sheep. When they had been steeped, that is, freed of the alkaloids, they could be used for other animals also. To-day the lupin in its alkaloid-free form represents a valuable protein fodder for all kinds of domestic animals.

Lupins are grown in Germany on the light, sandy soils, their arrangement, in order of increasing requirements as regards soil composition, being as follows: *Lupinus albus*, *L. angustifolius* and *L. luteus*. *L. albus*, the least exacting, tolerates a slightly acid to slightly alkaline soil (pH 6 to 7.5); *L. luteus* prefers acid soils with pH 5 to 7, while *L. angustifolius* occupies an intermediate position. Sensitivity to lime is a characteristic of all lupin species, and of *L. luteus* in particular.

The moisture requirements of lupins are relatively low, but they respond very well to large doses of water and will then give correspondingly abundant yields. Rainfall in the principal lupin areas in Germany varies from 400 to 600 mm.

Lupins grown for seed do not as a rule occupy any definite position in the cropping system. They are interpolated as a summer crop. The rotation in the lupin growing districts is: roots or tubers (potatoes), summer crop, winter crop (rye). Lupins are sometimes grown as the summer crop instead of oats or barley.

The seed is either sown alone or in a mixture with oats or summer rye. Cultivation with oats has proved very satisfactory in Germany within the last few years; the lupin seed crop, above all, is made more reliable thereby, the oats preventing the bursting of the pods in dry weather to a certain extent. The proportion of oats to lupin seed varies in accordance with soil and moisture conditions. The better these conditions, the smaller the proportion of oats required. Seed rate under favourable conditions is approximately 10 kg. oats and 160 kg. lupins per hectare; under unfavourable conditions 20 kg. oats and 160 kg. lupins per hectare. For pure sowing the seed rate is approximately 160 kg. per hectare in the case of *Lupinus luteus* and *L. angustifolius*, and 200 kg. per hectare in that of *L. albus*.

The seed is usually drilled in rows approximately 20 to 25 cm. apart, a distance chosen to facilitate machine-hoeing during early growth. Hoeing has proved especially valuable in the case of sweet lupins. The fields, which are normally very liable to become overgrown with weeds on account of the lupin's slow early development, may thus be kept clean.

Lupins are sown from the end of March to the beginning of April. The time of sowing appears to have a definite effect upon yield. Experiments at Müncheberg indicate that early sowing produces the highest yields.

Lupins are not exacting in regard to nutrient requirements. The application of nitrogen is unnecessary as lupins are "self-providers" of this nutrient. As they also have only a slight reaction to doses of potassium and phosphoric acid, these two nutrients are not absolutely necessary. Normally, however, dressings of approximately 80 kg. potassium and 50 kg. phosphoric acid per hectare are applied. Cultivation is limited to hoeing once or twice.

Harvesting is done in August or at the beginning of September. When there is abundant rainfall or a considerable amount of soil moisture, it may be postponed until the end of September, especially in the case of *L. luteus* and *L. albus*. It is advisable to mow *L. luteus* and *L. angustifolius* before full maturity as these species have a very marked tendency to shatter. In very dry harvest weather the lupins are mown either at night or in the morning dew. Self-binders or side-delivery reapers are used.

There is considerably less difficulty in the harvesting of *Lupinus albus*, the pods of which do not burst. With this species mowing can be delayed until every part of the field and every part of the individual plants are fully ripe.

After mowing, the lupin sheaves are arranged in stooks in rows or allowed to lie in windrows. It is advisable to cover the tops of the stooks with straw in order to prevent the bursting of the pods.

Carrying should not be done until the lupins are fully ripe, when they should be stored in barns or in stacks. The plants may easily become mouldy if the crop is carried while still moist; to prevent this, layers of straw are placed between the lupin layers.

Lupins are not threshed until the early spring, in order to prevent the seed becoming hard-coated. Within the last few years progress has also been made in the matter of hard-coated seed. We have succeeded in finding soft-coated lupins both in *L. luteus* and in *L. angustifolius*. As within a measurable space of time all sweet lupins will be soft-coated, threshing may be done in the autumn. The obtaining of good, germinable seed offers a considerable amount of difficulty. In Germany the "Schule" cleaning plant has proved satisfactory.

In breeding establishments seed may be scratched in order to improve swelling capacity and germination capacity.

When the cultivation of lupins is newly adopted in a district, inoculation of the soil or of the seed with nodule bacteria is advisable.

**Soybean
(*Glycine* species)****W. J. MORSE****United States
of America**

THE soybean has been an important crop for many centuries in Oriental countries, but it is only within recent years that it has claimed an important economic position in the agriculture and industry of the United States. The more extensive use of the crop for forage, pasture, ensilage, and in the manufacture of oil and oil meal and food products has resulted in an enormous increase in acreage and production of seed. Before 1917 less than 500,000 acres, including acreages interplanted with other crops, were grown in the United States. Production of seed was carried on extensively in only a few well-defined regions, much of the crop being grown in the Southern States. A fairly uniform development of soybean production took place in 1919 in the area east of the Mississippi River and in the first tier of states west of it. In less than thirty years the acreage of soybeans has increased more than a hundred-fold—from about 50,000 acres in 1907 to nearly 5.5 million acres in 1935. The most rapid increase in acreage has occurred in the Corn Belt States, Illinois, Iowa, Missouri, Indiana, and Ohio leading. In 1924, twenty-two states produced about 5 million bushels of seed and by 1931 seed production had increased to nearly 15 million bushels, the leading states being Illinois, Indiana, North Carolina, and Missouri. In 1935, about 40 million bushels were produced of which about 37.5 million bushels—92 per cent—were harvested in Illinois, Indiana, Iowa, Missouri, and Ohio. Illinois, Indiana, and Iowa produced about 87 per cent of the total 1935 production in the United States. In these states and North Carolina soybeans are grown quite extensively for commercial purposes, that is, used by oil mills in the processing of bean oil and bean meal.

Soybean acreage cut for hay increased from slightly less than 1.25 million acres in 1925 to more than 2.5 million acres in 1935, the largest hay sections being located in Illinois, Missouri, Tennessee, Iowa, and Indiana. The seeding of soybeans with other crops is largely confined to the Southern States, and in the more important hog-producing and dairy sections there is a considerable acreage devoted to soybeans in corn for pasture and ensilage.

The soybean is a profitable crop when grown for seed purposes, and the seed growing industry, other than for industrial purposes, has been developed extensively in many sections of the soybean region. The harvesting of seed has been one of the most difficult problems in the development of the industry. Until the advent of combines and special harvesters, growers of soybeans had to use the machinery at hand, with more or less unsatisfactory results. Within the past decade great strides have been made in improved methods of culture and machinery for planting and handling the seed crop.

In general, the best time to harvest for seed is when the leaves have all fallen, the pods are fully mature, and the seed is in the hard dough stage. When a special bean harvester or combine is used, it is necessary for the seed to reach full maturity to obtain the best results. The time of harvest, however, will vary somewhat with weather conditions. In a hot, dry autumn greater care should be exercised in the harvesting of varieties tending to shatter. Varieties of the non-shattering type can be left until fully mature in almost any kind of season with little or no loss of seed.

In the different sections where soybeans are grown largely for seed production, various methods of harvesting are used. The most successful of these methods include the grain binder, the mower, with or without a side delivery attachment, the self-rake reaper, special row harvesters, and the combine. The combined harvester and thresher, or combine had made great headway during the past few years in the large seed-producing areas. The advantages of using the combine as compared with other methods of harvesting and threshing are the saving of labour and the reduction

of harvesting costs, reduction in loss of beans, early clearing of fields for tillage and planting operations, distribution of the straw on the land, and earlier marketing of the beans. When soybeans are cut with a mower or self-rake reaper, the plants must be placed in small cocks to cure for four or five days or until the beans are found to be fairly dry in the pods. In the handling of the crop, during or after curing, the plants must be tough from dew or rain to prevent loss from shattering. Where a binder is used, the bound bundles should be shocked eight or ten to a shock, and allowed to remain until thoroughly dry.

The ordinary grain separator can be adjusted to thresh soybeans successfully, but if used as equipped for small grains it will crack a large part of the beans. Good judgment on the part of the operator will enable him to adjust the parts of the separator so that the beans may be threshed with little or no splitting. Some manufacturers have special pea and bean hulling attachments for grain separators which may be added at small cost. Special bean and pea separators of different sizes are used in many of the soybean producing areas. Soybeans if thoroughly dry can easily be threshed with a flail, and if the acreage involved is small, this method is practicable and economical. In the Southern States, where the soybean is grown extensively for seed, the harvesting from standing mature vines by special row harvesters, of which there are several types, is quite common. These machines are best adapted to harvesting varieties of the bush type grown in rows 32 to 48 inches apart, and when the seed is fully mature.

Soybeans spoil rather easily if not properly handled, and care should be taken in curing and storing the seed. Heating is especially liable to occur if the seed is bulked in large quantities in a bin or a poorly ventilated room, and it is almost certain to result if the beans are not fully dry when threshed. When the beans are dry and hard there is little danger of spoilage. When beans are sound, well matured, and practically free from foreign material, they may be safely stored in sacks or bins, with 14 per cent moisture. Unlike most peas and beans, soybeans are rarely attacked by weevils or other grain insects, except under conditions of excessive infestation.

Kidney Vetch **(*Anthyllis vulneraria*)**

F. CHMELÁŘ

Czechoslovakia

THIS species is cultivated for seed to about the same extent as white clover (1935 = 3,558 ha.). The main centre of its cultivation (see map in later Bulletin in this Series) is almost identical with that of white clover, namely, districts in the Czecho-Moravian highlands. The natural conditions are also similar. This centre extends far to the west into south Bohemia. In western Bohemia there is a secondary centre of much less importance, with about 600 mm. annual rainfall on podsol and stony soil. Smaller amounts of this seed are produced in southern Slovakia. The soil conditions are there similar to the above-mentioned centres, but the climate is more continental, with greater evaporation although the annual precipitation reaches 600 to 800 mm.

In view of its modest requirements regarding lime content and general soil fertility kidney vetch is grown on the poorest and driest sandy or stony fields. The average seed yield per ha. for the entire country (data of the State Statistical Office) is therefore rather low. In different years it fluctuates around 250 kg. (230 kg. in 1935) but if properly cared for, a crop produces about 4 to 7 q. per ha. The value of the total amount of seed produced in the Republic (8,359 q. in 1935) may be estimated at about 4 million Kč. annually (at a price of about 500 Kč. per q.).

Anthyllis is usually sown broadcast, but more careful farmers drill it in rows 12 to 20 cm. wide. The seed rate varies from 16 to 30 kg. per ha. Being sown in spring with a spring cereal as nurse crop, it blossoms from May to June and ripens in July and August. As the ripe seeds shed easily, the crop is harvested when the seed is still soft and cheesy and when the pods are just turning brown. Mowing is best done in the morning when the crop is wet with dew. Drying is done most carefully, as with crimson clover. Threshing and cleaning are rather easy, but broken seeds are still too frequent in the dressed seed. Kidney vetch seed fields may be used for 2 years, but generally they are used for seed only once, because after seeding many plants die off.

Seed of Moravian origin is well known abroad as being productive, winter hardy and very healthy and is exported in considerable quantities.

Vetches (*Vicia* species)

R. FLEISCHMANN

Hungary

Vicia sativa, grown mixed with oats for fodder, is still widely cultivated in Hungary, although this crop, which absorbs much of the soil moisture and gives a poor yield in dry years, is not always profitable. Many of the larger estates have relinquished it in favour of more lucerne, red clover and *Onobrychis sativa*, but the small farmers are still closely attached to the old, accustomed vetch-oats mixture.

Sowing is done in March or April by drilling in rows 4.5 inches apart for fodder, or 9 inches apart for seed. The seeding rate for fodder is 30 lb. oats and 100 lb. vetch per hectare; for seed, one-half this quantity.

The field is hoed once. Harvesting follows, for in dry weather the pods are apt to shatter; harvesting should therefore be done during the cooler hours of the day.

Harvest methods are similar to those used for cereals. Sheaves should be left in stooks for after-ripening, 4 to 10 days being sufficient, according to the weather. Threshing is done in July or August. Yields vary from 700 to 1,500 lb. pure vetch per acre; straw yields from 1,100 to 2,500 lb. per acre.

Only one cut is obtained. The total area in 1934 was 145,716 hectares, of which 18 per cent was devoted to seed production. The mean seed yield is 7.7 quintals per hectare.

* * * *

V. villosa has violet-coloured flowers. There is also *Vicia villosa* var. *glabrescens* Koch, which differs from *V. villosa* in that it has no bitter taste and is therefore more palatable to cattle, but it is more difficult to grow. The flowers are red-violet and the plant is glabrous. It is being tried at Kompolt.

V. villosa, like the glabrous vetch, is sown in autumn, generally with rye, sometimes with wheat. It is especially suitable for sandy soils. It is sown in September in rows 4.5 in. apart. The vetch should be sown deep, the rye to a more shallow depth over it.

The seed rate is 90 lb. vetch and 60 lb. rye per acre. A fodder cut is taken at the end of May or in June; a seed cut at the end of June or in July. Technique is as recommended for *Vicia sativa*.

As the pods open readily in dry weather, mowing should be done at night or during the cooler parts of the day. This is the more important because seeds which fall out constitute weeds of the crops which follow.

Bruchus viciae Ol. is a pest of crops in Hungary. The seed should be disinfected with carbon disulphide or cyanogen gas.

The total area in 1934 was 25,247 hectares, of which 19.9 per cent was occupied by seed crops. Seed yields averaged 8.9 quintals per hectare.

THERE are seven species of *Vicia* of which seed has been produced commercially in the United States. Three of these, namely, *V. villosa*, *V. sativa* and *V. pannonica*, have been produced in quite large quantities, while the others, namely, *V. monantha*, *V. atropurpurea*, *V. calcarata* and *V. dasycarpa*, have been grown only on a very limited acreage. *Vicia villosa* for seed is grown most extensively in Western Oregon, but lesser acreages occur in other states, particularly Michigan and North Carolina. Seed production of *V. sativa* is confined almost exclusively to western Oregon and western Washington, while *V. pannonica* is grown only in western Oregon. The small acreage of *V. monantha* and *V. atropurpurea* that has been used for seed production has been confined to north-western California and western Oregon, while *V. dasycarpa* has been grown only in western Oregon and *V. calcarata* in southern California.

There are no statistics for the amount of vetch seed produced but estimates have been made which probably are reasonably accurate. Production varies more or less from year to year by reason of seasonal conditions as well as the acreage sown. At the present time probably more seed is being produced by *V. villosa* than any other species, while formerly *V. sativa* was produced in the greatest amount. Estimates for maximum annual production are about 8,000,000 lb. for *V. villosa*, 6,000,000 for *V. sativa* and 1,000,000 for *V. pannonica*. The amount of the other species produced has always been much less, probably not exceeding 100,000 lb. for *V. monantha* and *V. atropurpurea* and much less for *V. dasycarpa* and *V. calcarata*.

The vetches in all regions for seed are sown in the autumn, September 15 to October 1 being the usual time, except in Michigan where earlier seeding is practised.

Seeding of vetch with rye or oats is usually practised, although it is not uncommon to grow the crop alone. In North Carolina *V. villosa* has been seeded with wheat, but in other regions this practice usually raises objections, as the wheat is difficult to separate from the vetch seed. When vetch is seeded with a small grain, the latter affords support for the vetch and facilitates harvesting. In Michigan, where *V. villosa* alone is grown, seeding with rye is common. In the Pacific north-west States seeding both with and without a small grain is practised. In the eastern United States the inoculation of vetch seed before planting is essential, but in the western United States this is not necessary.

The rates of seeding vetch for seed vary with the species and locality. In northern latitudes heavier seeding is required than in southern latitudes, while a greater amount is needed for species having large seed than for those with small. Usually only sufficient seed of the small grains is used to give support to the vetch crop, but in North Carolina where wheat is sown, this is harvested as a regular crop and the vetch seed is considered as secondary. In Michigan, where vetch is grown on sandy lands, light seeding rates are the rule. About 15 lb. of vetch and 40 lb. of rye are considered to be sufficient. In Oregon and Washington vetch is seeded at a heavier rate than in most other parts of the country and as much as 30 lb. of *V. villosa*, with 40 to 50 lb. of oats, and 60 lb. of *V. sativa* and *V. pannonica*, with 50 lb. of oats, are used. The seeding rates for *V. atropurpurea*, *V. monantha* and *V. calcarata* are about the same as for *V. sativa* and *V. pannonica*.

The harvesting methods used for the various species of *Vicia* vary slightly by reason of differences in habit of growth and degree of seed shattering. *Vicia dasycarpa*, *V. villosa* and *V. monantha* are much weaker in the stem than the other species and, therefore, cannot be handled so easily and sometimes not with the same machinery. *Vicia pannonica* and *V. atropurpurea*, having quite stiff stems that tend to be upright and having pods that do not shatter easily, can, especially when planted with a small

grain, be cut with an ordinary binder, although this practice is not common. The better seed habits of these species make harvesting by any method comparatively easy and the loss of seed light. In the Pacific Coast States the most common method of harvesting is to use an ordinary mower with a swather attachment. The swather, which is attached to and behind the sickle bar, rolls the vetch in a swath to the outside and leaves the way clear to cut the next swath. The vetch is immediately put into shocks and is left until threshed, unless a combine with pick-up attachment is used, in which case the vetch is left in the windrow. Special care must be taken in handling species which shatter easily like *V. villosa*, or much loss of seed will result. The most important rule in the growing of vetch seed is to handle the crop as rapidly and as little as possible after it is cut.

Vetch seed, whether grown alone or in combination with a small grain, is threshed with an ordinary grain thresher. In order to prevent cracking of the seed it is necessary to reduce the speed of the cylinder to 600 to 800 revolutions per minute and to remove a number of the concaves and cylinder teeth. The exact adjustments that may be necessary cannot be stated beforehand and must be determined at the time of threshing in accordance with the condition of the material to be threshed. In the Pacific north-west, combine harvesters are used quite satisfactorily for harvesting the non-shattering or semi-shattering species. These machines are equipped with attachments which pick up the cut material from the windrow and pass it on to the separating machinery. Combining standing vetch is not considered to be satisfactory because of heavy loss through shattering.

Vetches vary considerably in the yield of seed per acre. *Vicia saliva*, *V. pannonica*, *V. monantha*, and *V. atropurpurea*, in the Pacific Northwest, probably average from 600 to 800 lb. of seed per acre, while yields of 1,200 to 1,500 lb. are near the maximum. In that region, *V. villosa* and *V. dasycarpa* yield 300 to 400 lb. as an average and from 700 to 1,000 lb. as the usual maximum. In the eastern United States vetch seed yields are comparatively small. In Michigan, *V. villosa* yields from 100 to 250 lb. per acre and similar yields are the rule in North Carolina.

Lespedeza

A. J. PIETERS

United States
of America

THREE species of Lespedeza are grown in the United States and seed is harvested from them. They are the Common lespedeza (*L. striata*) with two varieties, Kobe and Tennessee 76; Korean lespedeza (*L. stipulacea*) and *L. sericea*. The first two species are annuals, the third is a perennial. Seed of Common is produced mainly in Louisiana and Mississippi, with smaller quantities in south central North Carolina, western Tennessee and western Kentucky. Seed of Tennessee 76 is produced in south central North Carolina and in western Tennessee, while seed of Kobe is harvested in various parts of Virginia and North Carolina, and in western Tennessee and Kentucky.

Korean lespedeza is grown mainly in the area bounded roughly by the southern border of North Carolina and Tennessee into eastern Oklahoma, and Kansas, and on the north by a line running just north of the southern border of Iowa. Practically no seed is produced in Ohio and but little in Indiana. Seed of *L. sericea* is produced in scattered localities from the Missouri, Ohio and Potomac Rivers to the Gulf of Mexico and into eastern Oklahoma and Kansas, with possibly a small production a little north of the Rivers mentioned.

No special method of culture is practised in the case of the annual lespedezas, where seed is to be taken. Fields that were intended for hay or for grazing may be used for seed production if the circumstances warrant. In fact, most of the seed of

common lespedeza taken in Mississippi and Louisiana is saved as an incident to hay harvest. This practice makes for an inferior hay, since cutting is delayed until most of the seed is ripe. Where better practices are followed hay and seed may be taken from the same field in one season by cutting the hay early and depending on a second growth for seed. The success of this practice, however, depends upon weather conditions. If there is enough rain, new growth comes on well; in dry weather there will be little or no second growth. Seed of Kobe and of Tennessee 76 is usually saved especially for the seed, the straw having some feeding value. Harvesting operations are similar in the case of all these forms of *L. striata*. Cutting is commonly delayed until just after the first frost, at which time the seed shatters readily. A "seed pan" is attached to the rear of the mower bar and a man rakes the cut material over this pan, shaking the lespedeza slightly. The ripe seed shatters off into the pan, which is emptied from time to time. The straw may be threshed if prices warrant or it may be fed. In any event the best seed is pan-caught.

Various devices have been built, many by farmers, to push the cut material over the pan and thus save the labour of the extra man pulling it over. Some of these devices are offered for sale. There is also a new machine which beats the seed from the ripe plants.

Cleaning is done with regular cleaning mills, using various sieves and wind control as may be needed. Dodder seed is the most difficult to remove, but experts with machinery can remove most if not all of this impurity.

The quantity of Korean lespedeza harvested exceeds by many times that of all other varieties together. In this case, unless the field has been allowed to stand into the winter a seed pan is not used, as Korean seed shatters very little.

Cutting is done with a mower and when, as in a dry year, the growth is very short, a fair way mower blade is used. The cut material is windrowed and cured in the field. Threshing is done as soon as possible after curing, and the seed is recleaned before marketing. A new small combine which cuts and threshes at one operation has just been put on the market.

Dodder is the most troublesome problem; the most economical method of control is to graze the fields heavily in late June. Cattle eat the dodder readily and the new growth is usually quite free from dodder. For the production of certified dodder-free seed it is necessary to go over a field several times during a season and remove the dodder by cutting out the infested areas.

Statistics on seed production are not very satisfactory and take no account of the quantities saved for home use only. The latest figures for 1935 contain no record of seed production in Missouri and Illinois, in which States considerable quantities are produced. Nor do the available statistics show the quantities separately of seed of each of the annuals produced. Some idea can, however, be obtained by considering that the seed taken in Mississippi and Louisiana is almost wholly common lespedeza, while that from other states is prevailingly Korean. In 1925, 46,000 acres were reported as harvested for seed in the states of Tennessee, Mississippi and Louisiana, more than half of this acreage being in Mississippi. The total production was 5,275,000 lb., 2,950,000 of this from Mississippi.

Korean lespedeza was introduced in 1921 and it was a few years later before seed production attained any volume. Seed production was not reported from Virginia, North Carolina and Kentucky until 1929, when 13,000 acres with a production of 1,950,000 lb. was reported from North Carolina, practically all of this being Korean. In the same year the acreage harvested in Mississippi fell to 4,000 with a total production of 450,000 lb. In subsequent years the acreage and production in Virginia, North Carolina, Kentucky and Tennessee continued to increase and that in Mississippi and Louisiana to decline. In 1935, the total acreage in the

four states mentioned was 287,000 with a total production of 43,150,000 lb., the increase being mainly due to the spread of Korean lespedeza. Meanwhile, the acreage harvested in Mississippi and Louisiana fell to 3,000 with a total production of 252,000 lb. It is estimated that in 1935 at least 12 million lb. of Korean were produced in Missouri, and nearly 2 million in Illinois, which are not reported in available statistics.

Yields of seed vary widely, depending on weather conditions and care in harvesting. The average good yield of Common is about 200 to 250 lb. per acre while Korean yields 300 to 400 lb. and has been known, on a small well tended acreage, to yield, 1,200 lb. of clean seed per acre.

L. sericea is too recently introduced to make it possible to estimate production. When grown for seed alone it is seeded in rows and cultivated in the first year. Treated in this way, a crop of 300 to 400 lb. per acre may be taken in the year of seeding. When seeded in close drills or broadcast on grain no seed is secured in the year of seeding, but each year thereafter for an indefinite period a hay and a seed crop may be taken. The quantity of seed produced is less in broadcast stands than when seeded in rows, but yields of 400 to 600 lb. may be expected when conditions are suitable.

Harvesting is done by mower with windrower attachment or with binder or combine. Cutting is done about or just after the first frost and when about 75 per cent of the seed is ripe. While the seed shatters to some extent, care in harvesting and especially in preventing the team or tractor from passing over the cut material will reduce this to a minimum. The material cures readily and with good weather can be passed through a grain thresher or a clover huller after 2 or 3 days' curing.

When the first growth is allowed to seed, the stems are tall and coarse and trouble is largely obviated by cutting the first growth for hay and the second for seed.

When threshed in a grain separator the seed is mostly in the hull; where a clover huller is used it is hulled and scarified. The unhulled seed can be used for autumn and winter seeding, but for spring seeding scarified seed must be used. The unhulled seed can be hulled and scarified in commercial scarifiers, which are usually available in the chief centres of production. A loss of 25 to 30 per cent in weight occurs in hulling. Seed is offered by the seed trade both as unhulled and as scarified seed.

